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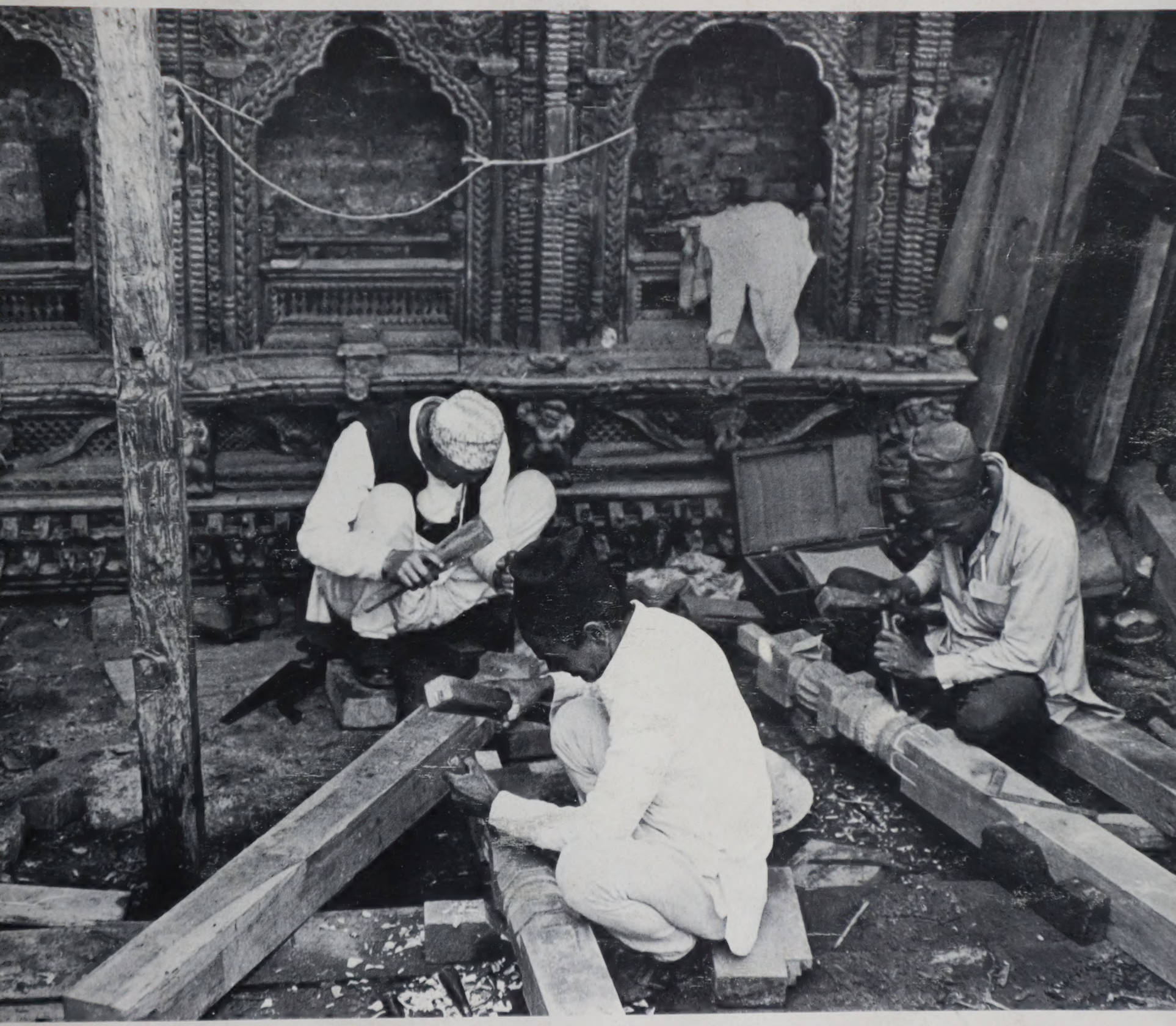

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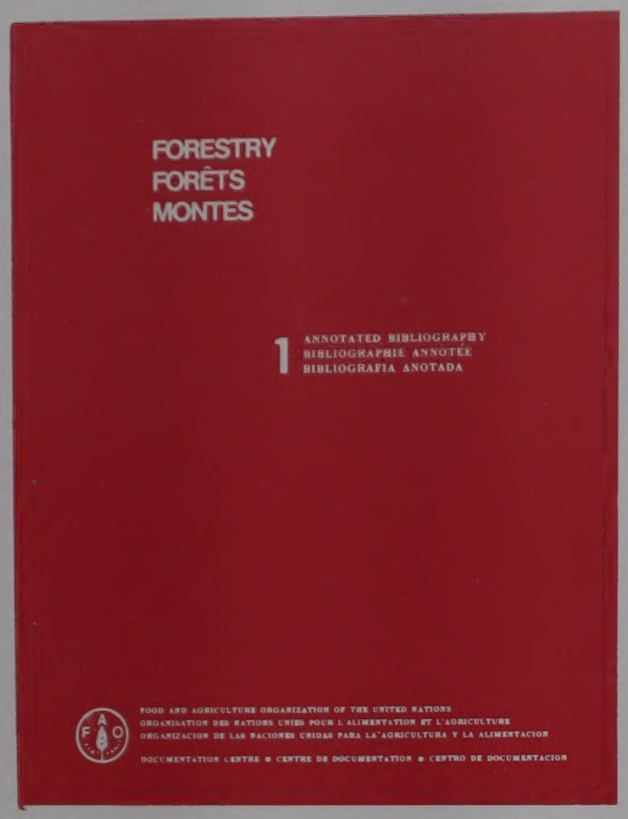
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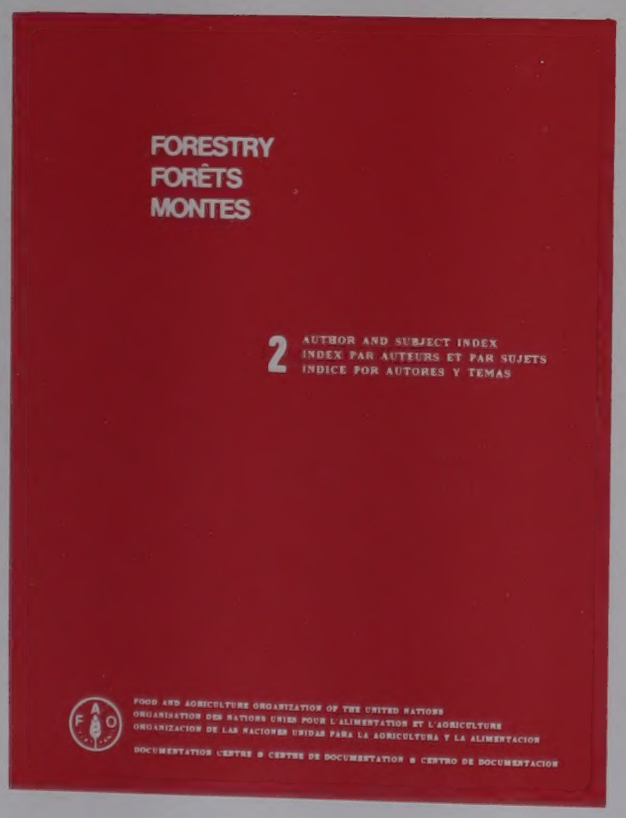
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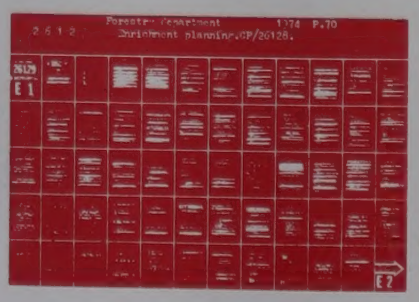

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COVER: Restoring an ancient building in Bhaktapur, Nepal

Photograph by R.O.A. Becker-Ritterspach

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The restoration of Bhaktapur

R.O.A. Becker-Ritterspach

By common consent, the Himalayan country of Nepal is a source of constant delight. The medieval settlements of the Kathmandu Valley still preserve to a large extent both their ancient environment and their traditional way of life. The temples, palaces and even the houses of its historic cities show an unerring artistic instinct, especially in the lavish use of carved wood. This woodwork is not just surface ornament, but is integrated functionally into the buildings.

The period from the 16th to the 18th century was the golden age of Nepalese architecture and craftsmanship. Since then, there has been a decline; as has happened in so many areas, the old crafts are dying out. Modern materials and construction methods, cement and metal sheeting are supplanting increasingly expensive timber. An austere business-like style is driving out the ornate products of a more leisurely age. Indeed, it seems that this survival of the ancient culture of Nepal is destined to disappear except for fragments in museums. The potential tragedy is not only the loss of irretrievable works of art but a loss of cultural identity as a result of uncontrolled change.

In a day of scientific and technological achievements and widespread desire for higher standards of living, people everywhere in the world expect better housing, sanitation, social amenities and opportunities for employment. In the rush of efforts to achieve these goals, traditional buildings, no matter how valuable they may be artistically, are in danger. One of the great challenges of economic and technical development is the salvation of these treasures using the materials, tools and techniques of advanced technology.

Housing in Bhaktapur in a state of collapse, and a city reservoir

The three main centres of the Kathmandu Valley — Bhaktapur, Patan and Kathmandu itself, the capital — are artistic cities suffering from decay. Of these, Bhaktapur calls for special attention because it is in a better position to preserve its character than the other two cities.

Up to the second half of the 18th century, Bhaktapur, 15 km from Kath-

RAIMUND O.A. BECKER-RITTERSPACH is an architect and deputy head of the Federal Republic of Germany's team involved in the Bhaktapur Development Project in Nepal.

mandu, was a power in the land and a thriving centre for trade, especially with Tibet. Then the centre of power shifted, the city lost its tributary land and after the construction of a highway to the capital was by-passed by trade routes. The decline of Bhaktapur was gradual but steady. Even now, the more active elements tend to move to Kathmandu or to the new centres of growth in the Terai lowlands, which lie in the south near the Indian border.

The nature of decline and shift of activity to the other two cities has meant that Bhaktapur has possessed neither the incentives nor the means for the kind of large-scale urban development that might have emphasized the repair of its architectural glory. Damage to buildings due to neglect has been compounded by the ravages of earthquakes and inherent factors such as moisture, the great enemy of wood. Weak foundations, lack of moisture barriers, leaking roofs and insufficient links between timber elements and masonry are among the main problems. Perhaps even more serious is that, even where they survive, the old crafts, which are closely linked to the caste system, have shown themselves unable to innovate. The result is that structures still continue by and large to be erected in the old traditional ways.

Fortunately, a determined effort is now being made to remedy this state of affairs, in particular by the Bhaktapur Development Project, which was launched as a venture of His Majesty's Government of Nepal with the assistance of the Federal Republic of Germany. The latter is represented by the German Agency for Technical Cooperation which has commissioned Systemplan Ltd. and ARGE Systemplan-Prack to carry out the first and the second phase respectively of a project to bring Bhaktapur back to life and beauty. The costs for construction work for the two phases are 15 million and 23 million Rupees to be shared between the two countries: one third by Nepal and two thirds by the Federal Republic of Germany. The Government of Nepal covers counterpart expenses and administration, while the costs of German technical staff and certain equipment are covered by the Federal Republic of Germany. The first phase began in July 1974 and ended in October 1976. The second phase carried on from the first and will end in October 1979.

Restored building becomes a tea house

Although the repair of existing buildings and the revival of the ancient crafts are central to the project, the aim of the operation is not to turn the city into a kind of glorified museum. It is to improve the physical, infrastructural and socio-economic conditions of the people of Bhaktapur while at the same time preserving the medieval character of the town. It was clear from the beginning that what was needed was a comprehensive plan which would take into consideration and give equal importance to both development and preservation. The proper perspective and a balanced approach are essential if both objectives are to be harmoniously achieved.

The key concept is to carry out planning and implementation concurrently, and, during the first two-year phase, this policy proved successful. After an initial period of trial and error, the planning benefited from experience gained from ongoing work.

Every effort is being made to combine the preservation of artistic treasures with the provision of income, employment and better living conditions. Thus, much time and energy has gone into the improvement of the water-supply system as well as into traditional open wells and ponds, sewerage, sanitary facilities, housing and construction of school buildings. A handicrafts centre is already in operation, to be followed by small industries. A restaurant has been opened in a beautiful building which has been tastefully restored and a second restaurant will follow. In short, it is understood that unless new life can be infused into the ancient body of this still largely agricultural town, the vigour needed for the restoration of temples and houses will lag.

The project has made a special effort to improve traditional house construction. The guiding principle in devising new methods has been to make use of existing skills, technology and construction methods wherever technically possible. The project has collaborated in a number of private house repairs and reconstruction works by giving aid in design as well as subsidies in the form of material and labour. During the work, house owners and project staff have had a chance to carry out and appreciate the improvements in techniques and

structures. One advantage which was immediately realized was the saving in timber permitted by the project's methods. Even so, people were hesitant to adopt new construction methods. They wanted to be sure that these new ways would give results at least as good as the traditional methods.

Two demonstration house units were designed and constructed incorporating the structural, functional and aesthetic elements worked out by the project as well as typical elements of the traditional architecture. The purpose of this plan was to demonstrate that is was quite possible to use modern methods in construction, while maintaining the traditional appearance of the building. Some of the elements incorporated in these units were the overhanging roof supported by struts; the traditional proportions of windows, doors and other timber elements; and the unplastered brick walls. But, most important of all, these houses were meant to show that it was vital to preserve the character of each area as a whole, so that all the units blended to produce the overall effect, and conversely that no single unit detracted from that effect.

These units were also used to bring home the point that they had not been erected to provide something to be slavishly copied, but used as a general guide for the kind of improvements which everyone should adapt to his own needs when building his own house.

After a stay in a demonstration house for a specific period, selected families are in a position to testify to the effectiveness of the improvements and innovations. But this measure was supplemented by a drive to convey the message to housebuilders, craftsmen and local officials, indeed to the whole population, by means of slides, leaflets, posters or lectures.

The other drive to restore traditional architecture to something approaching its former splendour was for the preservation of old buildings. The project sought to achieve this aim by preserving certain ensembles of buildings in their entirety, and also, on a more immediate basis, to repair some damaged or dilapidated structures and objects. During the first phase of the project, the historic Dattatreya Square was completely restored, as well as a number of individual structures. During the second phase, several smaller groupings will be renovated.

Farmers who live in the city; in November the streets are covered with newly harvested rice

How new building techniques are introduced

The guiding principle at the Bhaktapur Development Project for the introduction of new methods has been to make use of existing skills, technology and construction methods wherever technically possible. The project has designed a number of technical improvements which reduce the amount of timber used in buildings while increasing the lifetime of building materials employed. These are a few examples.

- Ceilings: The number of joists is reduced by increasing the distance between them and by using "standing sections" instead of "flat" sections. Moisture barriers are used below wall plates and ventilation head and joints.

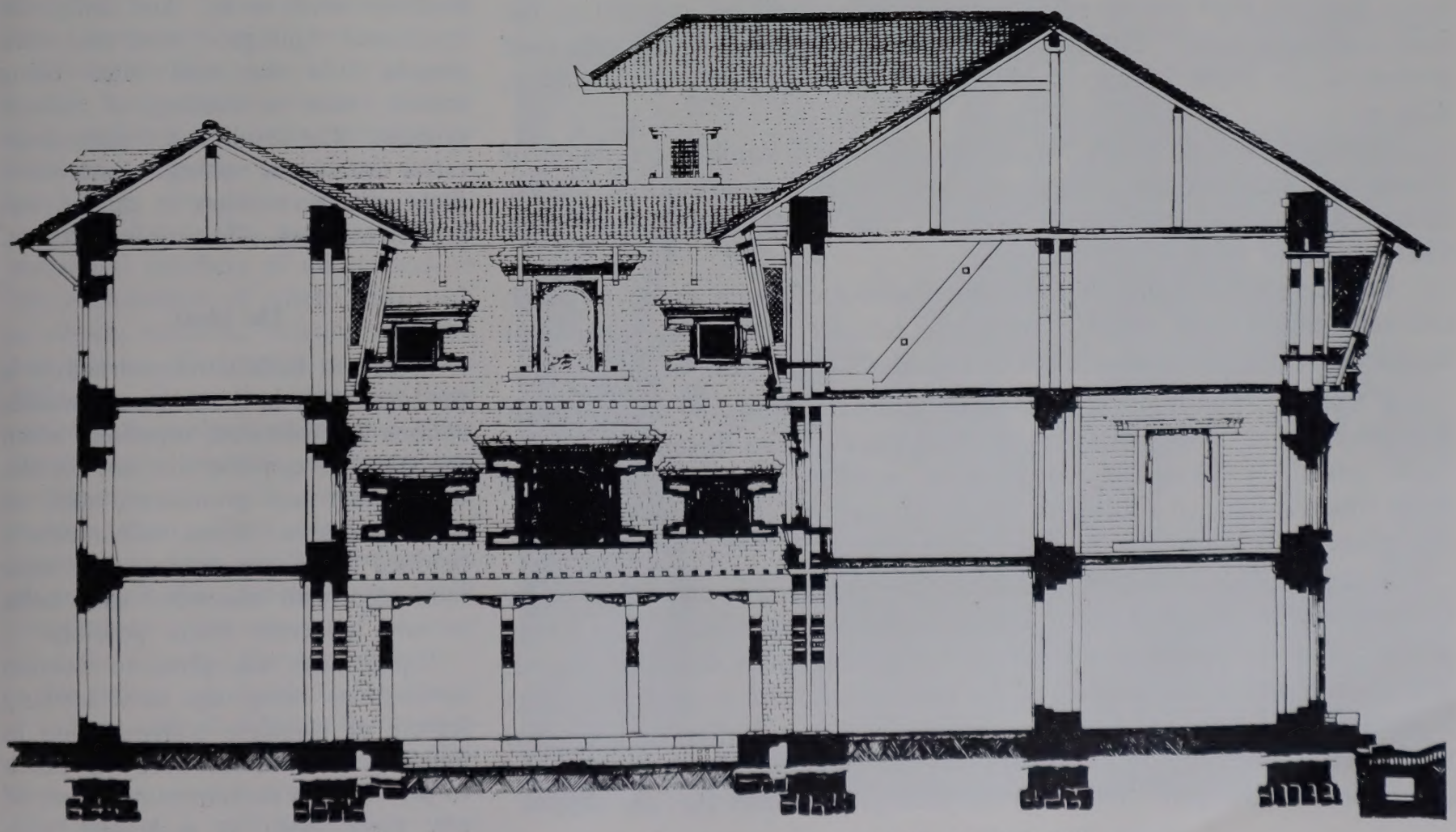
- Roofs: Modern purlin/rafter construction is employed using large roof tiles and reinforced ring beams to fix purlins.

- Windows, doors, pillars and stairs: There is a reduction of sections following structural requirements. More glazed windows were used, double windows were designed, window mesh was introduced, stairs were redesigned for easier climbing, and plywood was used for such items as doors and cabinets.

- Joints: Traditional pegs were replaced with pegs which reduce the loadbearing capacity but which themselves carry little load. Nails, iron bolts and rods were employed.

- Timber preservation: Treatment with multipurpose preservatives gives protection against fungi and insects.

Detail of peacock window



Architect's drawing of the restored Sukhuldoka Math building

An old capital restored

A newly carved capital

Structural elements in traditional buildings

The traditional house in the Kathmandu Valley is a two to four storey unit set among others in rows along a street. Usually each house has two bays separated by a centre spine wall set parallel to the front and back walls. The skeletal structure is covered with a tile roof pitched at an angle of about 35 degrees. Ceilings are low — 1.80 to 2.20 m.

Elements such as doors, windows, pillars and lintels were made of timber and incorporated structurally into brick masonry walls. These timbers are covered with ornate carvings that disguise with beauty their vital structural roles.

Loadbearing elements of the ceilings and roofs were made of much heavier timbers than strictly required, because the artisans were not technically equipped to measure exact needs and stresses.

- Ceilings: The flooring joists span bays of 2.20 to 2.80 m and their flat sections (10 × 7.5 cm) rest on wall plates. The distances between these joists are 10 to 15 cm in order to allow a sub-flooring of flat brick which is finished with 10 to 15 cm of clay or, in exceptional cases, clay tiles.

- Roofs: The purlin/rafter construction employed is characterized by a broad roof overhang of about 1.20 m supported by struts. The laying of the rafters is similar to the laying of the roof joists described above. The internal structural support of the roof is designed in such a way as to keep the roof space free from obstructing elements. Rafters are covered with a layer of split timber or bamboo that carry a 10-15 cm layer of clay. Small "jhingati" roof tiles are then pressed into the wet clay.

The aim has throughout been to preserve as much of the original substance and cultural importance as possible. The structural condition of most of the buildings called for a comprehensive revision. Many buildings had thus to be partly or even completely dismantled. The task of reconstructing the buildings in exactly their previous form entailed an overwhelming amount of paper work and documentation.

It became obvious at this stage that, in order to avoid the structural damage resulting from the use of traditional methods, certain innovations would have to be introduced. Emphasis was therefore laid on a whole range of measures which will keep future maintenance down to the minimum and at the same time ensure that the buildings last for a considerable period. These innovations include better roofing, stronger foundations, moisture barriers and efficient timber treatment against rot, fungi and insects. Special attention was paid to the roofing as the most vulnerable factor. The rafters were covered with planking, and double tarfelting applied in hot bitumen. This was then covered with a layer of mud treated with herbicide in order to prevent plants from sprouting on it. And lastly, the traditional "jhingati" roof tiles were pressed into the mud after being treated with a coating of silicon syltrete. The result is a highly decorative waterproof roofing. Such comprehensive restoration is carried out only on buildings of historic importance.

The ideal

Total and faithful reconstruction is the ideal, but, in many cases, modifications are tolerated, especially when the parts in question are not visible, or at least not prominent, such as roof structures. Some visible details retained their appearance, but were reinforced with concealed steel bolts or with concrete where possible.

Top priority was given to wooden carvings as being the most striking feature of Nepalese craftsmanship in building. The utmost care was taken to preserve the maximum substance of any piece, both as such and with regard to its structural context. Often,

this approach led to serious problems because, in most cases, the wooden parts have load-bearing functions. Various technical devices had to be employed in order to save weak parts or even whole elements. These means included the injection of hardening substances or the mounting of the parts on invisible reinforcements. Inevitably, a number of carvings were found to be beyond repair and had to be reproduced. This was a big problem at the beginning of the project. The standard of work demanded for reproduction of the carvings was so high that only a few carvers were capable of executing it, and many of those were seriously out of practice. The earlier work in Bhaktapur by the German specialists, and a parallel project on the old Royal Palace at Kathmandu (by Unesco) had fortunately set the ball rolling, but the number of skilled workers available was pitifully small. During the peak season, the project employs about 200 carpenters, most of whom can do carving, but are otherwise nonskilled.

New artisanry encouraged

Old artisanry valued anew

Four-armed goddess and restorer

Cleaned and preserved

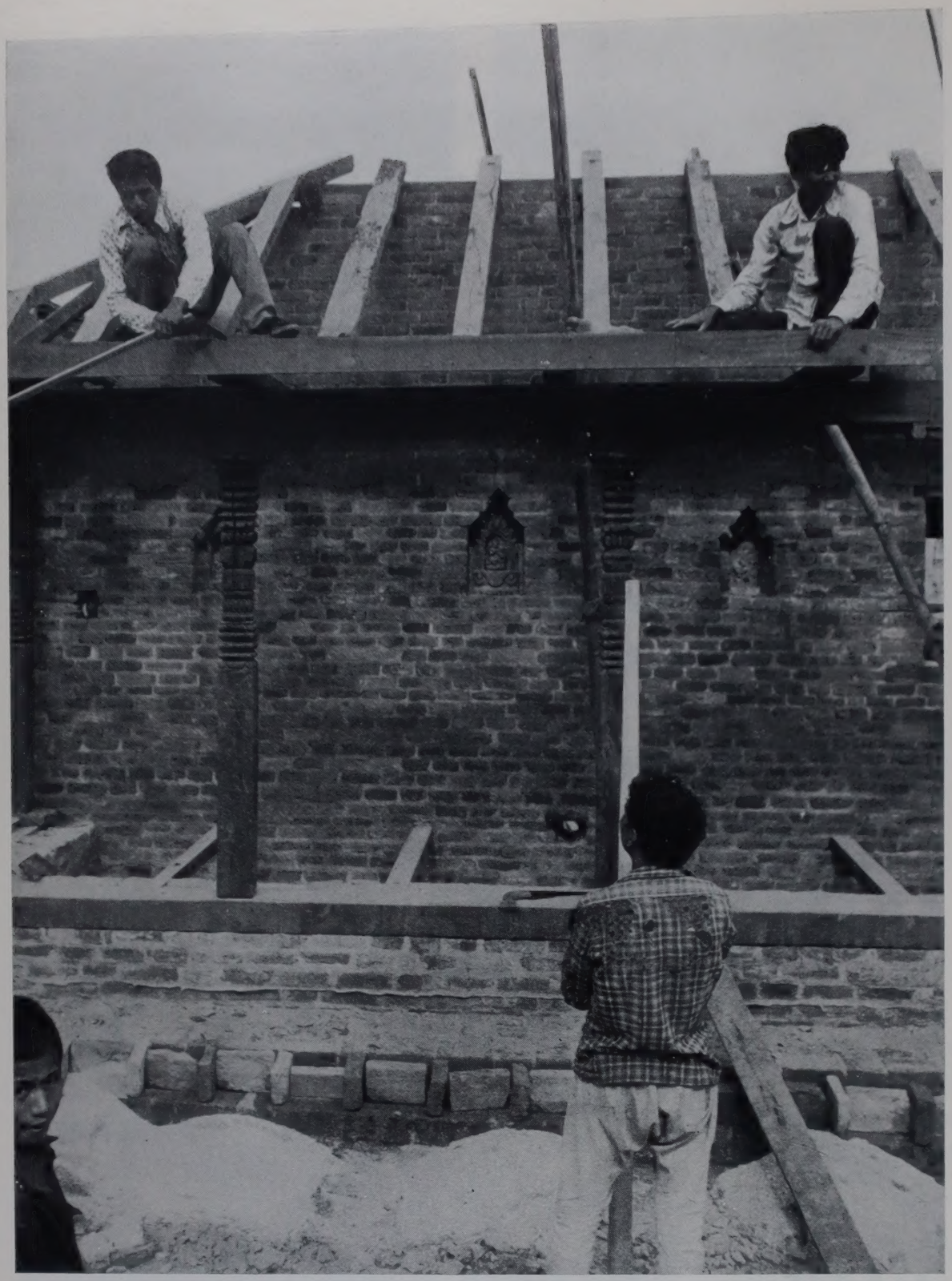
The last stage of the repair consisted of skilled cleaning and subsequent treatment with preservative under the close supervision of a chemist.

During the first phase of the project, twenty large monuments and numerous small objects were restored or repaired. Carving accounted for a very large proportion of the work, ranging from the replacement of individual members of an element to the manufacture of whole units such as doors, windows, balcony windows and pillars. The repair presented no difficulty. Once the elements were removed from their setting, they came apart easily because in traditional architecture no nails were used in making them. They were made of interlocking parts which were held in place until the masonry was built round them. The completed masonry gave the wooden elements rigidity.

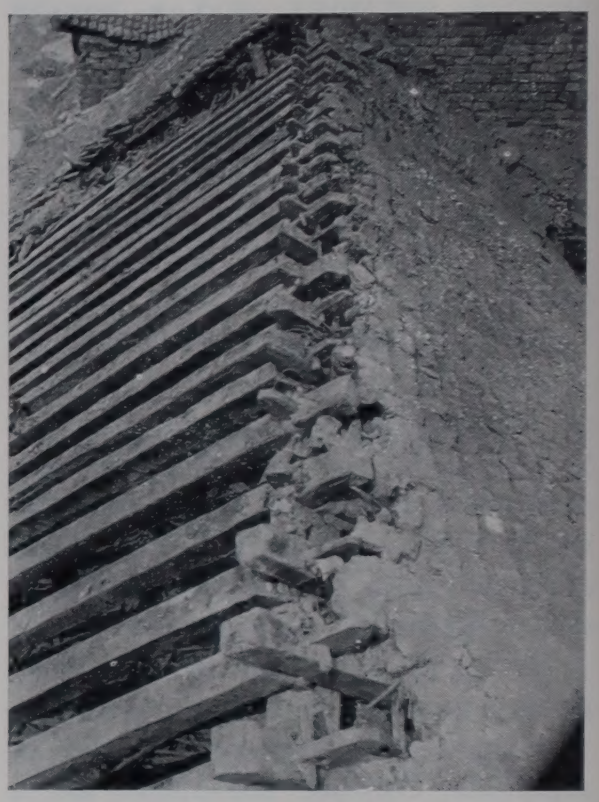
The project can clearly be considered a success only if it helps to create a corps of highly trained artisans. The task is by no means easy. The trainee must accept a new technology and new methods of work. He often

must also acquire a new respect for his cultural heritage, which has been weakened by the glamour of modern and prestigious currents of thought and practice.

The project accordingly lays great emphasis on the training of craftsmen and workers, generally in the building trades, in new methods which can be applied to traditional-style buildings. The programme tries to achieve this objective by on-site training. There is also special training in up-dated technology which covers the recording of all existing work methods, the development of new ones based on traditional techniques, the introduction of foreign work methods and their adaptation to local needs. Stress is laid on keeping production and maintenance costs low, on saving forest resources, and on safety measures against damage by earthquakes, as well as on modern timber engineering. Special lectures and seminars are planned for various levels of professionals, officers, overseers and craftsmen, supplemented by the distribution of appropriate literature. Lastly, a small-scale timber industry for prefabricating door and window components and perhaps parts of roofing is being considered in order to provide additional employment. Furniture, too, may be manufactured. The creation of this centre will give a new



Every building combines masonry, carpentry, wood and stone carving



Traditional roof seen from above

Carpentry in Kathmandu

The equipment used has hardly changed down the centuries. All timber is cut, planed and worked by hand. The main carpentry tools are the flat axe, pad saw, adze, and a number of locally designed wood-carving implements. Machinery is uncommon except in carpentry shops equipped with circular saws and band saws. Prefabrication of house components is relatively unknown. It is possible, however, to order window and door elements from workshops in advance. Generally the workshops arrange for a carpenter to proceed to the site and install the elements ordered and to assist in the installation of ceiling joists and roof members.

impetus to the need for skilled craftsmen, and, by ensuring employment, hope to attract new hands into this type of work.

The training covers construction as a whole, but particular attention is given to timber as a key building material and one which is susceptible to deterioration and decay.

Another aspect of the preservation of traditional skills is the creation of a handicrafts centre, manned by, among others, skilled carpenters who have formed themselves into a co-operative. This co-operative produces excellent carvings for sale to tourists and for export. In this way, they will stay together as a team for repair and restoration work on monuments and other buildings. The centre also includes hand weavers, painters and makers of masks and puppets.

Repaving brick streets

Resetting an ancient stone arch

Despite the prevalence of modern trends in construction, there is no doubt that timber will continue to be used extensively in Nepalese architecture. The demand will come not so much from public buildings and high-standard housing (though the revival of woodcarving will lead to a fair use of wood in the doors and windows), but from ordinary housing which will be very much in the market for timber components. And this is not just a matter of fashion. The new building code specifies that houses built in the historical parts of all towns must conform to certain mandatory standards which include sloping tiled roofs. The owners themselves generally build the houses or supervise the design and construction. This class of owner generally favours wood for doors, windows and stairs, because it is easy to work and handle and can be transported by the cheapest form of transport available in these parts — which is man himself.

The main obstacle to the continued use of wood on an extensive scale for building is its increasing cost. Steps will therefore have to be taken to alter the present policy on timber consumption. In earlier days, timber for the Kathmandu Valley was felled in the valley itself or in the surrounding hills. With the growth of population and the consequent demand for housing this supply disappeared. Now virtually all construction timber is felled in the Terai foothill forests, a considerable distance from Kathmandu. As logging moves to more remote areas, timber costs rise and are increased by the greater amounts of expensive fuel oil needed for the logging and transportation equipment.

From June to October there is a market shortfall in timber production owing to the monsoon rains. Reserves are gradually depleted, and acute

shortages develop just after the monsoon ends and the new building season starts.

But there are still other factors making for high timber prices. At present, the timber for building comes from a small number of "primary species" such as Sal (*Shorea robusta*) and Asna (*Terminalia tormentosa*). These species, which account for more than 70 percent of the total consumption, are harvested in such a way as to put excessive pressure on the country's forest resources. Lastly, seasoning and grading of construction timber are virtually unknown in Nepal. In order to avoid twisting, builders use larger timber sections than are really necessary for the job in hand. Chemical treatment of timber is not widespread because of the high natural durability of Sal, which is the basic construction timber.

Chemically treated "secondary species" could perform well and their use would make it easier to extract wood from the forest reserves more efficiently. Moreover, these species have a lower specific gravity, and are hence less costly to transport as well as offering various other technical advantages.

Brahmayani Dyochen restored

Provided forest management is improved and the range of supply extended as suggested, timber should continue to be important in Nepalese architecture in line with the encouragement now being given to people in Bhaktapur to revive the riches of the national cultural heritage. Should the present success of the German-assisted project in that city continue, as there is every likelihood it will, both recipient and donor will have the satisfaction of achieving three objectives at the same time: the strengthening of an age-old culture by a judicious blending of old and new techniques; the economic revival of a declining town; and the creation of a large number of jobs. It will also fill with pride not only those who fashion timber into objects of beauty, but also those who have the good fortune to enjoy the fruits of these craftsmen's labours. ■

Centre of Bhaktapur after restoration

Toward predictability in agro-climatology

Orman E. Granger

Over the past few years global climate, traditionally treated as a static environmental element of little but academic importance, has acquired international prominence because of the recent erratic behaviour of weather and the impact it has had on world food and energy reserve, on water resources and international politics. Devastating droughts in the Sahel, in the USSR, and in India, south Asia, north China, Central America, the Caribbean and California; excessive rainfalls and flooding in India, Bangladesh, and the midwestern United States; abnormally warm or cold winters, destructive winds and shortened growing seasons in other parts of the world caused loss of life and economic depression.

These apparently unheralded climatic aberrations sparked an upsurge of reports, papers and general inquiries because previous short runs of mild winters in much of Europe, the southern and midwestern United States and other regions had helped to create an attitude of scepticism about the science of climatology: that is, though it might be interesting, its practical implications for today's world was questionable. This attitude was reinforced by the fact that, with some exceptions, most of the years between 1956 and 1972 were blessed with remarkably favourable climatic conditions for agricultural production, particularly in North America, and for forest products in most of the tropics and mid-latitudes. But variability is an inherent characteristic of climate, and not to be perceived as unexpected, abnormal or anomalous. Further, climate is an important resource not to be taken for granted — a resource whose behaviour is not yet well understood and whose variability is accepted

ORMAN E. GRANGER is a climatologist in the Department of Geography, University of California, Berkeley.

TABLE 1. **Stations used in calculating areal means of seasonal precipitation**

	Latitude	Longitude
California stations		
Sacramento	38°35'	121°30'
Fresno	36°46'	119°43'
San Francisco	37°47'	122°25'
Santa Cruz	36°59'	122°01'
Salinas	36°40'	121°36'
San Luis Obispo	35°18'	120°40'
Santa Barbara	34°26'	119°50'
Los Angeles	34°03'	118°14'
San Diego	32°44'	117°10'
Mexican stations		
Mazatlan	23°12'	106°25'
San Blas	21°50'	105°15'
Guadalajara	20°36'	103°23'
Acapulco	16°50'	95°55'
Salina Cruz	16°10'	99°12'

but not yet predictable with a high degree of precision.

Many scholars are agreed that the decrease in global temperature evident since 1940 after almost half a century of warming will continue to bring with it increasing variability of climate through the rest of this century and into the next. Some climatologists think that this downward trend in global temperature may be leading to another ice age, if not of the magnitude of the Pleistocene epoch certainly of the magnitude of the "Little Ice Age." In support of their claim they cite the sudden increase in snow and ice cover in the northern hemisphere, circumpolar vortex expansion which blocks the intrusion of humid tropical air into monsoon regions, the higher frequency of droughts in tropical and subtropical areas and decreases in the length of growing seasons to mention a few. Others see the cooling trend and other patterns as a result of extra-terrestrial causes such as sunspots, although it is not yet known exactly how this causal mechanism is linked to climatic fluctuations.

There are also those who see the present climatic fluctuations as having planetary determinants: the frequency of volcanic eruptions, man's input of pollutants and aerosols into the atmosphere, the dramatic increase in CO_2 concentration attendant on an indiscriminate burning of fossil fuel and the complete disregard in some regions for ecologically sound land-use policies. Still others hold that climatic fluctuations can be considered as random events: that the climatic future is indeterminate or that the earth-atmosphere-hydrosphere-cryosphere system has inherent in itself, through feedback mechanisms, the ability to move from one well-differentiated state to another through ephemeral states so that deterministic dynamics as now applied may very well be an exercise in futility. In short, we may never be able to predict any one micro-state of the system until we have a complete grasp of the details of all possible micro-states.

We may not know exactly what the climatic future will be, but that does not completely rule out climatic outlooks with probabilistic bases. We can legitimately take the position that it is precisely in this operational form that the results of climatic investigations become of utmost importance in policy and management decision making, in averting possible disasters and setting up economic expectations. The risks and ambiguities have to be evaluated in the same way as is done in other situations. Forest management decisions and expectations with respect to forest yields and regeneration are cases in point.

There are innumerable studies demonstrating the strong relationship between productivity and primary climate variables, Drozdov (1971), Jordan (1971), Watson (1963), Chang (1968a, 1965, 1968b), Bazilevich *et al.* (1968) to list a few, and in all of them the underlying message is that primary productivity is closely related to the variability and fluctuations of climate. Further, it has been demonstrated that

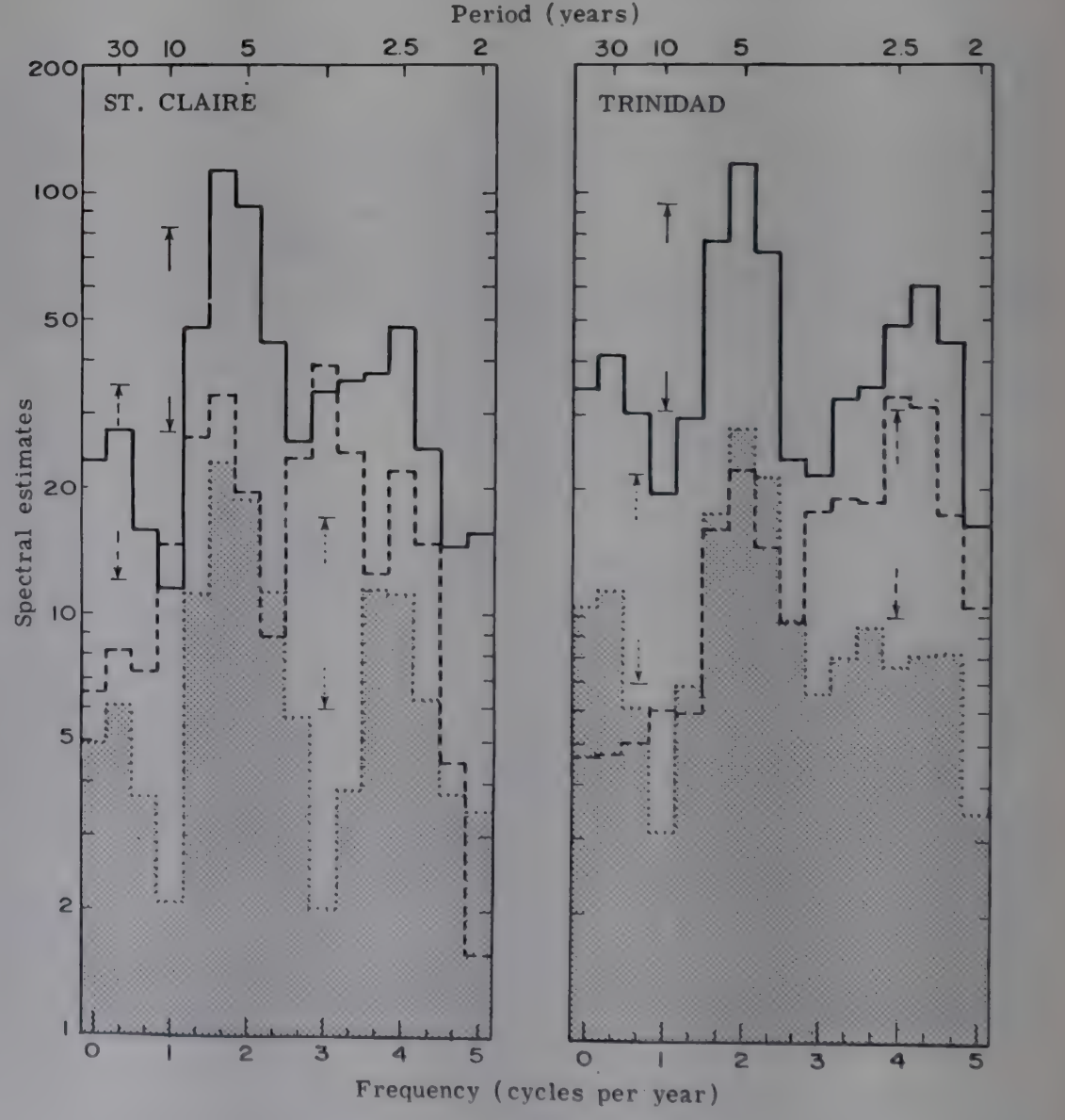


Figure 1. — Power spectrums of the annual dry season and wet season precipitation series for the period 1921-70 for St. Claire in Trinidad, West Indies, and for the island as a whole.

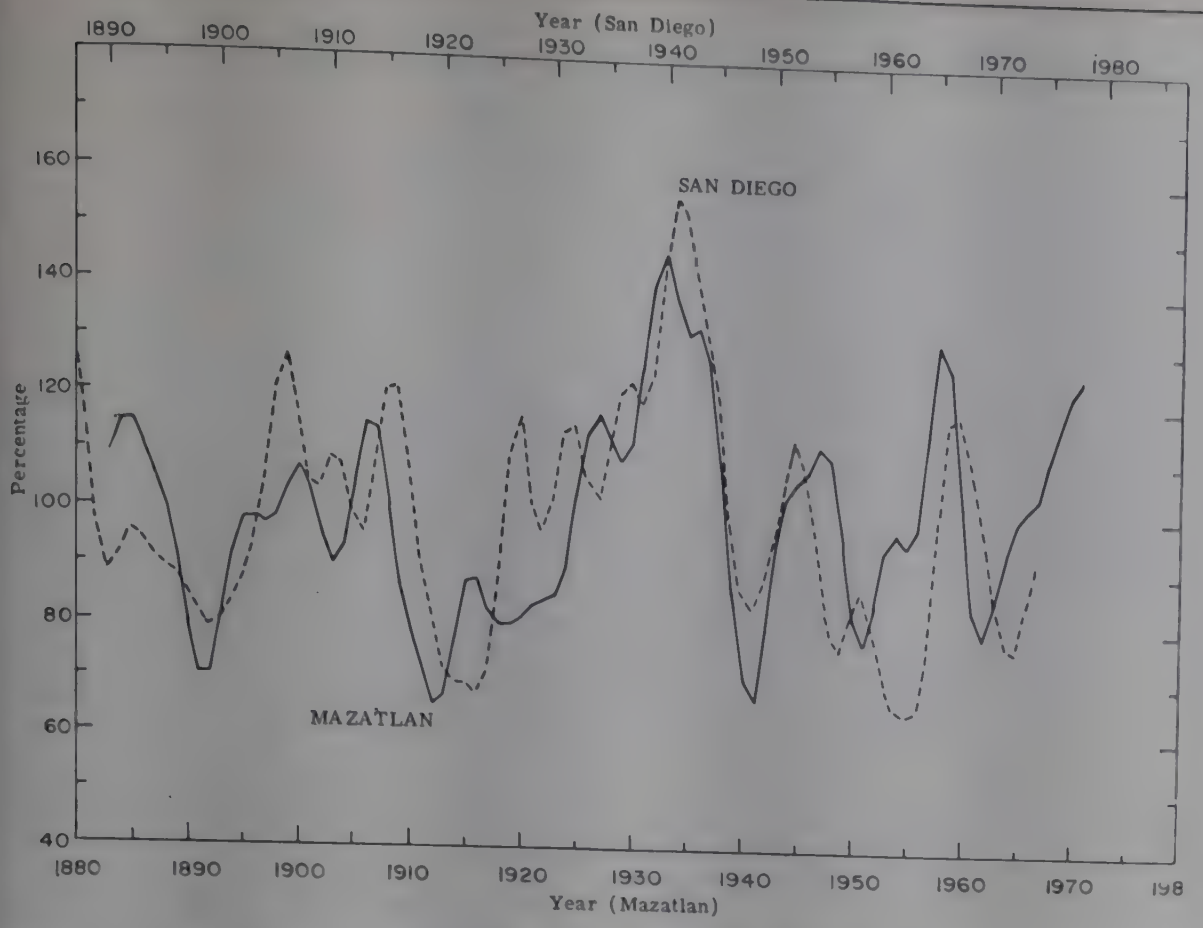


Figure 2. — Binomially smoothed seasonal precipitation expressed as percentages of the long-term mean for San Diego superimposed on that for Mazatlan lagged by 7 years. Note the time shifts on the abscissae.

climatic variability is most marked in semi-arid and sub-humid regions of the earth and because of the climatic sensitivity of these areas, they may very well be the most effective barometers of large-scale trends.

Leith (1973) and Leith and Whittaker (1975) have constructed models which predict the net primary productivity of vegetation over land areas from average annual temperature and precipitation. These models have so far performed admirably when their results are compared to those obtained through other approaches. Leith (1976) used the models to predict the possible impact of changes in both temperature and precipitation on net primary productivity in latitudinal belts of 10° from 70°N to 40°S latitudes. The results show that global net primary productivity may change by as much as 5% with simultaneous temperature changes of 1°C accompanied by a 6% change in rainfall. Of this 5%, about 1.6% are due to temperature changes and 3.4% to rainfall changes. Rainfall changes generally have greater impact on global vegetation than temperature changes although there are latitudinal differentiations. Leith cites the 8% productivity change in the 60-70°N belt as due almost entirely to temperature against the 5% change in the 0-10°N belt, almost all of which was due to precipitation change.

Based on the present state of knowledge with regard to future climatic fluctuations, average annual temperature changes of several degrees and precipitation changes in the order of several tens of percent may be expected (Lamb 1966, Mitchell 1974, Johnsen *et al.*, 1973). The first half of the twentieth century appears to have been a temporary respite from the more "glacial" conditions of the period 1600-1900 and the climatic character of the mid-nineteenth century might provide a better estimate than the 1931-60 or 1941-70 "normal" as to what the next two decades will be.

From their investigation of climatic oscillations between A.D. 1200-2000, using the isotopic composition of glacier ice from the Camp Century ice core as a climatic indicator, Johnsen, Dansgard and Clausen (1970) concluded that if we neglect "accidental events" and the effects of large-scale atmospheric pollution, there is a more than 85% probability that the cooling trend will continue in the next 10-20 years, followed by an increasing tendency reaching a peak between 2010 and 2020. Hubert Lamb and Tadashi Asakura have argued that cooler periods are marked by higher climate variability while Reid Bryson has produced evidence that drought frequency in northwest India in the twentieth century is correlated with cooling in high latitudes. Although the issue of a "cooling trend" is still controversial, it is becoming increasingly apparent that predictive models that enable us to better deal with the uncertainties of climatic variability will be more crucial in the next two decades than they were in the period 1931-60.

On the basis of sun-spot cyclicity, Willett (1976) predicts that over the next 25 years: (*a*) the temperatures in all latitudes will fall to significantly lower levels than those reached in the mid-1960s (he is uncertain as to whether the fall will start immediately, reaching its lowest level in the 1980s, or start in the 1980s and bottom out in the 1990s); (*b*) no major prolonged drought will occur in lower middle latitudes, except possibly along the subtropical margins of Mexican border States of the United States; (*c*) a predominantly dry period during the next two decades in higher middle latitudes, particularly in Canada and northern Europe, and in subtropical latitudes, with a decade of severe drought likely in southern Asia and subtropical Africa. He further predicts that between 2000 and 2030: (*a*) there will be an abrupt return to markedly warmer weather in middle and higher latitudes during the first decade of the next century, followed by a return to low temperatures, but the warmth of this period will not approach that of the 1931-60 period in intensity; (*b*) the warm decade of 2000-2010 will tend to be wetter in higher, middle and subtropical latitudes, but drier in lower middle latitudes; (*c*) the return to cooler conditions during the 2010-2030 decades should witness also a return to relative wetness in lower middle latitudes and relative dryness in higher middle subtropical latitudes. It must be pointed out that, so far evidence for and understanding of sun-spot/climate relationships have not been sufficiently convincing. However, we are not justified in dismissing the approach completely. If these predictions turn out to be even partially correct, it is evident

that there will be large areas of the world that will suffer some adverse effects. Some areas may be harder hit than others and some may even be devastated unless some type of climatic warning system is available on a yearly basis.

Granger (1977) has shown that there have been significant quasi-periodic fluctuations in California precipitation in the past 100 years. There have been periods of marked dryness lasting from 3 to 6 years and correspondingly marked periods of wetness and it is expected that these patterns will continue in the immediate future. From the data series it can be demonstrated that extreme variability is characteristic of periods of decreasing hemispheric temperature. Similar quasi-periodic oscillations showed up in the precipitation series of Trinidad, West Indies, and in the water balance series because of concurrent fluctuations in temperature there] (Granger, 1971). These oscillations result in an average of four years of comparatively large moisture deficits, ~ 40 cm, during the dry season, followed by a year of low deficit, ~7.7 cm (Figure 1). Since 1957, however, there has been a trend toward greater aridity concurrent with a net temperature decrease of, ~1°C.

The studies cited above, together with those of Kraus (1954, 1955, 1958), Trenberth (1976), Longley (195)3, Bradley (1976), Krueger and Gray Jr. (1967), Lamb (1966), Hastenrath (1967), Winstenley (1973b), Bunting, Dennett, Elston and Mulford (1976) to list a few, clearly indicate that both temperature and precipitation have fluctuated in the past over large areas of the world and one can infer from these studies that similar fluctuations will occur in the future. Moreover there is strong evidence for parallelism in the behaviour of climatic regimes of different regions, for example, between African and Asian monsoon regimes particularly along their arid margins (Kraus, 1971) and between the Old World and New World summer rainfall regimes (Byrne, Granger and Monteverdi, 1978).

The inescapable conclusion is that the devastating droughts in the Sahel, the USSR, California and other areas of the world in the 1970s have to be accepted as part of the normal climate of these regions and their recurrence

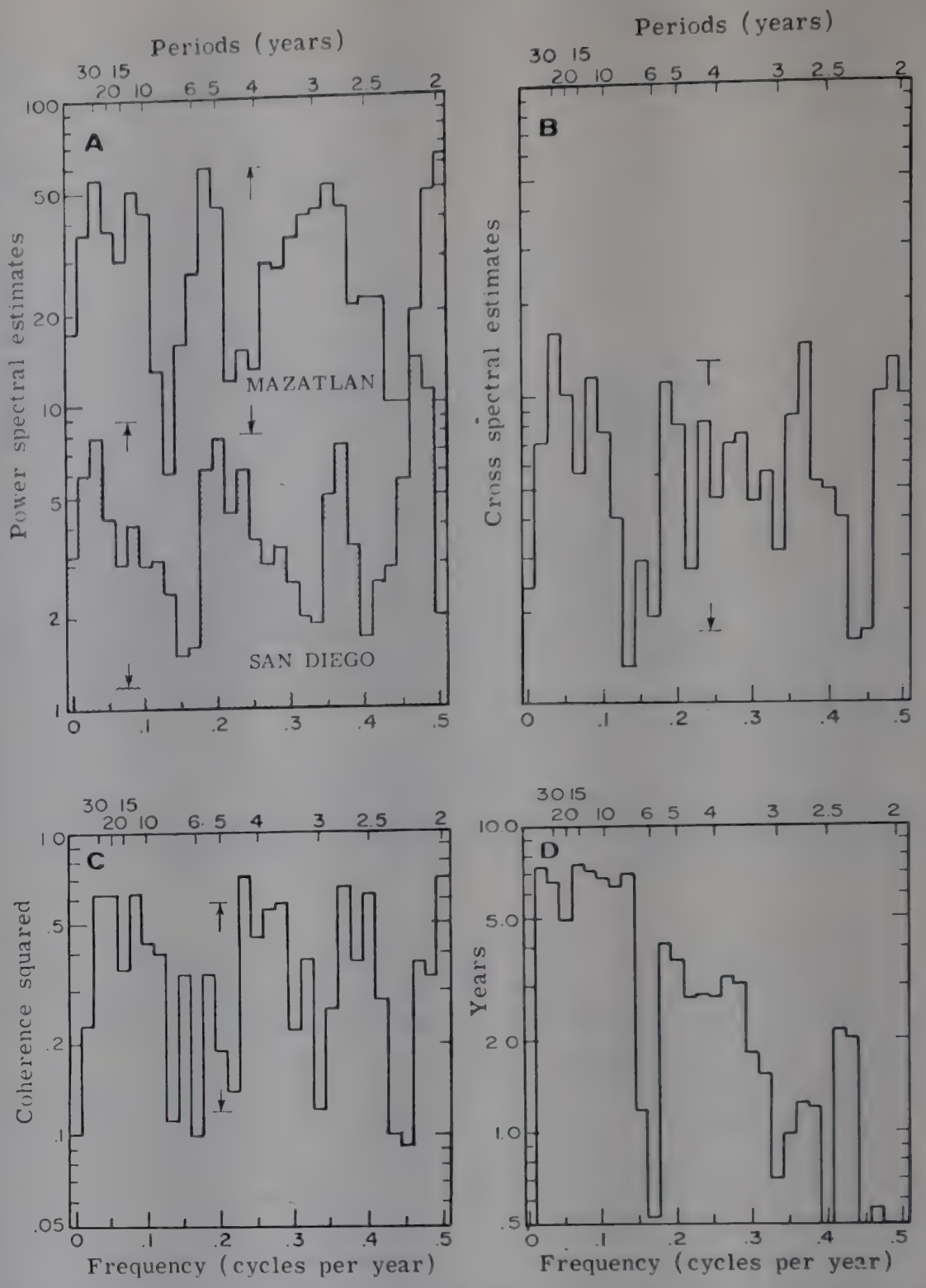


Figure 3. — (A) Power spectra of the seasonal precipitation time series for Mazatlan and San Diego, (B) cross-spectrum of the same two series, (C) coherence squared between the two series with Mazatlan as the independent series and (D) phase shift in lag time between the two series with Mazatlan coming before San Diego.

should therefore be expected. It should also be realized that the period 1931-60, which is taken almost universally as the standard of comparison, was a period of greater than average rainfall in most areas of the world. If we accept the premise that the impact of climatic aberrations can be minimized if and when their occurrences can be predicted, the challenge reduces to the basic tasks of formulating robust predictive models and of evaluating the extent of social and economic disruption associated with climate perturbations of different levels of magnitude and intensity. Granger, Byrne and Michaelsen (1978), in an attempt to meet the first of these two challenges, devised a model for California from the results of investigations by Byrne, Granger and Monteverdi (1978).

These latter investigators, in a comparative analysis of recent rainfall trends in the Old World and New World subtropics sparked by the work of Winstanley (1973a, 1973b), uncovered an unexpected 7-year lag effect between summer rainfall in north central Mexico and winter rainfall in southern California. However, the strongest lag correlation was apparent in rainfall series that had been smoothed by 5-year running means and therefore susceptible to the Slutzky-

Yule effect. The results for two stations are shown in Figure 2. Granger, Byrne and Michaelsen (1978) explored the lag further both in the frequency and time domains, using cross-spectral analysis which isolates all possible scales of differentiation of the fluctuation of the data series, and lag correlation analyses.

The data set consisted of (*a*) the seasonal totals of precipitation (May through October for the Mexican stations, and November through April for the California stations) of Mexican and California stations shown in Table 1 for the period 1880-1973; (*b*) seasonal totals expressed as percentages of their long-term mean to make the values from the two regimes comparable on the same scale; (*c*) area averages of percentage seasonal precipitation; and (*d*) weighted moving averages of seasonal percentage precipitation with weights proportional to the binomial coefficients for six terms. The California stations were chosen on the basis of the homogeneity of their precipitation regimes as indicated by inter-station correlation coefficients and coefficients of variation while the choice of Mexican stations was based on Wallen's (1955) classification of Mexican rainfall regimes and corroborated by inter-station correlation analyses.

Spectral estimates with fundamental periods of 2 $m\Delta t$ were obtained for frequency bands 0.0167 cycles per year wide for $m = 30$ and $\Delta t = 1$ year. The raw estimates were smoothed by "hanning." The null hypothesis of a white noise continuum was adopted because the first order auto-correlation function was not significantly different from zero nor was there evidence of Markov linear type persistence. The 95% and 5% confidence limits for each spectrum were calculated according to the sampling theory developed by Tukey (1950). The phase and coherence squared were also calculated. The results are shown in Figure 3. Four prominent bands characterize the spectra although only the 2.0-2.1 year band reached a-priori statistical significance. The peaks at 2.1 and 5.5 years add to the already considerable spectral evidence for oscillations in meteorological variables related to precipitation in the central and northern Pacific with similar periods (Wagner, 1971; Angell and Korshover, 1974; White and Clark, 1975; Trojer, 1960; Portig, 1958; and Belarge, 1966).

The cross-spectrum and coherence squared (Figures 3b and 3c) show strong association between the two series at periods of 15-30 years, 12 years, 4.3 years, 2.7 years and 2.1 years. The coherences squared for these periods are all higher than 0.60 and are significantly different from chance occurrences. The time phase spectrum (Figure 3d) shows that the lower frequencies (0.017 to 0.133 cpy) have average phase shift in lag time of ~ 7 years, while the medium frequencies have lag times between 3 and 4 years. These latter lag times, in sum, produce a beat frequency with a lag of 6.8 years.

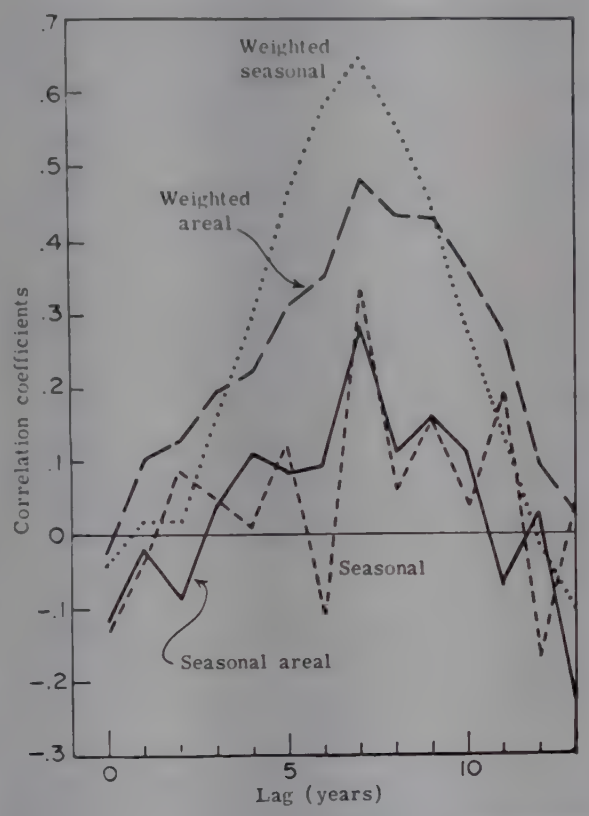


Figure 4. — Lag correlation coefficients against lag time in years between Mazatlan and San Diego for seasonal and weighted seasonal precipitation, and between the Mexican area and California area for areal seasonal and weighted areal precipitation.

These results corroborate the findings of Byrne, Granger and Monteverdi (1978), and lead to the hypothesis that lag effect suggested in the Mazatlan-San Diego analysis may be extrapolated spatially since the selection of stations in both regimes was predicated on homogeneity and high interstation correlations. Lag correlation coefficients between Mazatlan and San Diego for percentage seasonal precipitation and between the Mexican area means and the California area means for the same variable were therefore calculated. In addition the binomially smoothed series were similarly analysed. The results are shown in Figure 4.

Summer precipitation at the selected Mexican stations is negatively correlated at lag zero, but highly positively correlated with winter spring precipitation at the selected California stations seven years later. The correlation coefficients at lag 7 are significant at the 1% confidence limit with tests that take account of the effects of serial correlation and changes in degrees of freedom dye to smoothing (Quenoille, 1952; Bartlett, 1946). The similarity of results in both the frequency and time domains indicates that the 7-year lag is statistically real. However, it is apparently related more strongly to the lower frequency (periods of 7 to 30 years) variances in the two rainfall series.

The 7-year lag effect was incorporated into regression analyses using all but the last eight years of the precipitation series (1880-1973) to produce predictive equations, leaving the period 1966-76 to be used as an independent test. The regression of San Diego seasonal precipitation on corresponding Mazatlan seasonal precipitation seven years before produced an equation with significant correlation coefficient but with a large standard error and small variance explained. This was not unexpected because of the noise in the seasonal precipitation series and the nature of the 7-year lag indicated above. The weighted averages for San Diego, P_{sw} when regressed on the weighted averages for Mazatlan, P_{mw} lagged by 7 gave:

$$P_{sw} = 0.658\, P_{mw\text{-}7} + 35.3 + 16.2\%; \quad r = 0.60,\ n = 73 \qquad (2)$$

To test the stability of the correlation, the data sets were split arbitrarily into two periods, 1880-1920 and 1921-65. The resulting relationships are respectively:

$$P_{sw} = 0.421\, P_{mw\text{-}7} + 56.9 + 14.6\%; \quad r = 0.38,\ n = 35 \qquad (3a)$$

and

$$P_{sw} = 0.765\, P_{mw\text{-}7} + 24.3 + 17.1\%; \quad r = 0.67,\ n = 39 \qquad (3b)$$

The correlation coefficients are significant at the 1% level using the Bartlett

formulation to allow for serial correlation in the time series and for reduction in numbers of degrees of freedom. The difference in the correlation coefficients may be due to the 19th and early 20th century precipitation in California differing somewhat from that of the later period (Granger, 1977).

Smoothed areal means for the whole period (1880-1965) and for the subperiod (1921-65) were subjected to an absolute error e, and a root mean square error RMSE, were calculated. The results are shown in Table 2. The predictive performance of the equations is quite good. The null hypothesis that the mean of the observed and forecast samples were not significantly different could not be rejected at $p < 0.01$ on a F-ratio test. As an additional test of the predictive consistency of the lag effect, Los Angeles

TABLE 2. **Forecasts of smoothed seasonal precipitation** [1]

Weighted mean centred on	Oi	Equation (2) Fi	(3b) Fi	Oi	Equation (4a) Fi	(4b) Fi
1965	100.6	121.8	124.9	93.0	109.7	111.7
1966	118.2	118.5	121.0	105.3	108.2	109.7
1967	118.6	102.7	102.7	116.3	100.7	99.8
1968	109.5	89.7	87.5	121.3	94.7	91.9
1969	99.4	87.1	84.5	118.1	93.4	90.1
1970	87.6	91.4	89.5	106.4	93.8	90.8
1971	77.7	97.2	96.3	95.6	94.1	91.1
1972	77.4	101.2	100.9	97.3	94.7	91.9
1973	85.4	102.2	102.1	107.1	96.4	94.1
1974	93.1	103.8	103.9	106.2	99.2	97.9
1975		109.2	110.2		104.0	104.2
1976		115.9	118.0		109.7	111.6
1977		118.2	120.7		111.8	114.4
		e = 4.8%	= 4.6%		e = —7.9%	= —9.8%
		RMSE = 16.1%	= 16.9%		RMSE = 14.7%	= 16.8%

[1] Using equations 2 and 3b and 4 together with verification scores expressed as average absolute error e, and root mean square error (RMSE). The season is given in which the January-April period falls.

regression analysis as before and produced respectively:

$$P_{cwa} = 0.696\,P_{mwa\text{-}7} + 30.9 + 13.4\%; \quad r = 0.51,\ n = 73 \qquad (4a)$$

and

$$P_{cwa} = 0.919\,P_{mwa\text{-}7} + 7.7 + 15\%; \quad r = 0.48,\ n = 34 \qquad (4b)$$

where the sub-scripts C = California, M = Mexico, A = Areal means, and W = weighted cumulative averages. Again the correlation coefficients are significant at the 1% level.

Equations 2 and 3b and 4a and 4b were used to predict the smoothed seasonal precipitation of San Diego from that of Mazatlan and the California areal from the Mexican areal for the independent test period 1966-76. Verification scores expressed in terms of and Sacramento which lie 190 km and 780 km respectively from San Diego were selected. Following identical procedures as for equations 2 and 3b, predictive relationships were derived. The outlooks based on them are consistent with those for San Diego and have similar statistical characteristics. We have demonstrated elsewhere that results from the statistical relationships given above can, with care, be mathematically disaggregated to provide actual seasonal precipitation estimates. The outlook for 1977-78 based on one such disaggregation appears to be more accurate than outlooks produced for California by other researchers using other methods.

Despite the accuracy of the equations the problem of causality still remains unsolved although a solution was, and is being vigorously sought. We are convinced that the lag effect is related in some way to the time and space distribution of sea-surface temperature anomalies in the north Pacific. Unfortunately, comprehensive sea-surface temperature data for a sufficiently long period are not now available to provide adequate resolution on the times scales over which the lag appears to be most important. Michaelsen (1977) has found some significant relationships but they appear to be temporally unstable.

We further suspect that the lag effect is part of a global-scale coupling between tropical and mid-latitude systems. Studies by Nicholls (1977) in Australasia and Namias (1957) in north-western Europe found similar though shorter lags between tropical and mid-latitude systems. The California-Mexico precipitation connection is evidently a complicated one as evidenced by the result of the frequency domain analysis and several mechanisms may be involved, and from the results of Byrne, Granger and Monteverdi (1978) it is probable that an analogous connection with similar forcing mechanism(s) exists between analogous areas in the Old World. We are at present exploring the nature of these connections as far as available data will allow.

As far as we know the foregoing approach to seasonal precipitation outlooks has not been used elsewhere; we do know, however, that it provides California with a seven-year lead time in seasonal precipitation outlooks which is potentially advantageous to water resource planners, agriculturalists, forest management experts, and all those concerned with water availability in central and southern lowland California. If results from research now underway confirm that the lag effect is more than just a north Pacific phenomenon, similar outlooks for other areas of the world will provide an invaluable input into forest management decisions. ■

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Must Africa suffer the environmental consequences of tsetse-fly control?

TSETSE FLY (*Glossina* spp.)

Antoon de Vos

In Africa, where the ecological equilibrium is known to be extremely delicate, tsetse control agencies should be particularly on the alert for any undesirable results or side-effects of eradication schemes. The continent's growing need for food, due to its fast-rising population, calls for an expansion of meat production but animal trypanosomiasis is, at this time, preventing cattle raising in most of tropical Africa.

Animal trypanosomiasis and human sleeping sickness are spread by tsetse flies (*Glossina* spp.), which inhabit a broken semi-humid and humid belt stretching across the continent from the Atlantic to the Indian Ocean.

The Food and Agriculture Organization (FAO) of the United Nations, in cooperation with various other assistance agencies, is launching a campaign for the eradication of these diseases and of the tsetse fly. If successful, cattle herds alone could be boosted from 100 to 120 million head, the supply of milk would increase considerably and protein scarcity could be greatly reduced.

Unfortunately, as yet there exists no simple, foolproof and cheap method for the eradication of carrier flies without causing some harm to the environment.

Control of these diseases can be achieved either by drug treatment of the host or by eliminating the vector, or a combination of both. The selective breeding of resistant cattle is another possible approach.

Two methods of tsetse control were being used until recently — bush clearing and wildlife destruction. They have been almost entirely dropped because they were found to be ineffective.

The thinking behind bush clearing was that the modification of the fly habitat would inevitably result in the disappearance of the flies. Although this was a correct assumption, many projects involving bush clearing failed to bring the expected result because,

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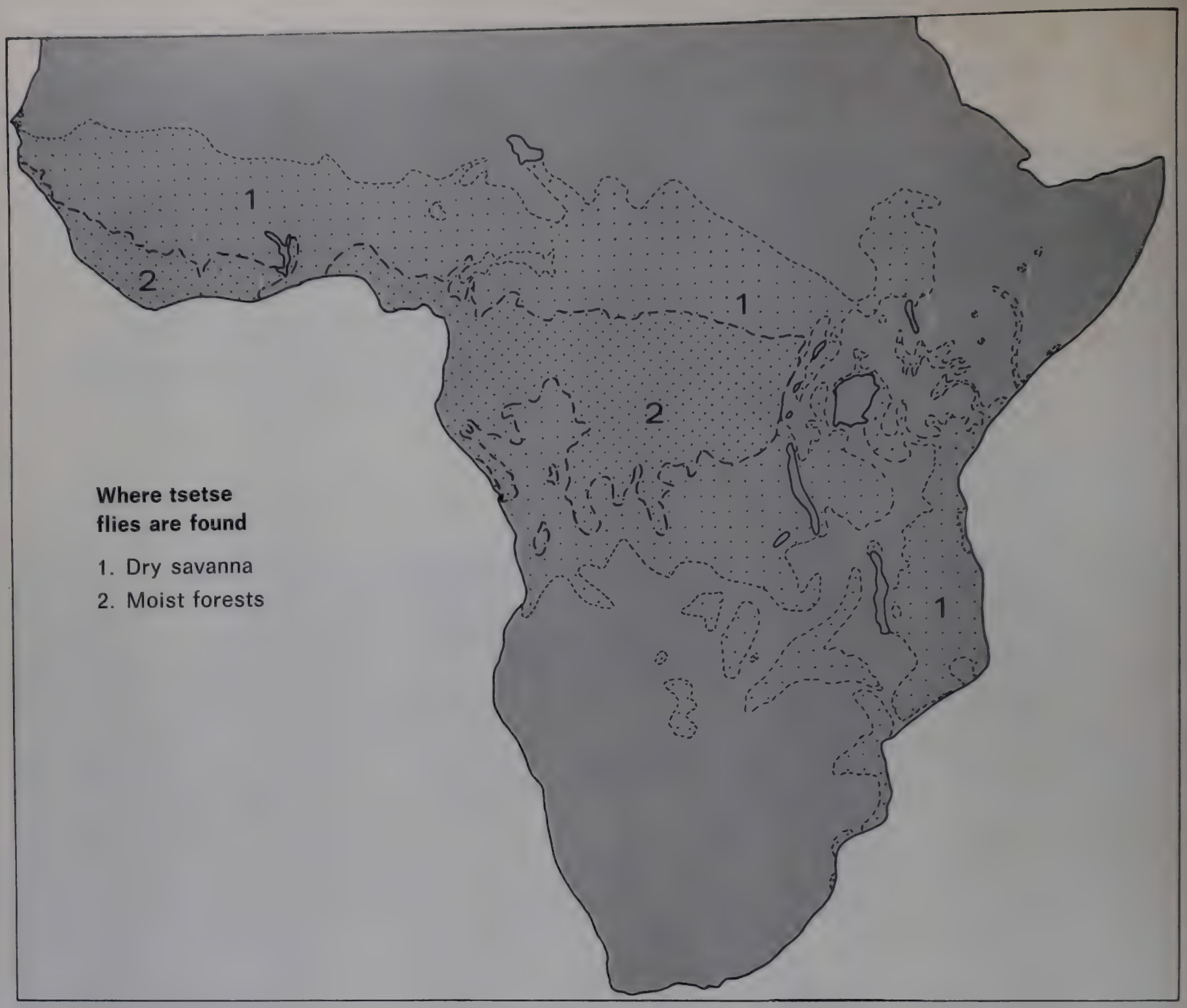
Eradication of trypanosomiasis aims at expanding meat and dairy production for an increasing African population. But similar efforts in the past have resulted in wasted resources, severe environmental damage and needless slaughter of wildlife, after which the tsetse flies returned worse than before. The present campaign should safeguard the natural environment. But most important, it should be a part of integrated land-use and development operations so that cleared land will actually be utilized for agriculture and settlements and not abandoned again to ever worse tsetse infestations.

SEARCHING FOR TSETSE-FLY SPECIMENS IN BOTSWANA
keeping land cleared is not easy



THE AFRICAN TSETSE ZONE
Can the land that is cleared actually be settled?

once the trees and shrubs were removed, follow-up efforts to maintain the areas in a cleared condition were omitted or inadequate. As a consequence, bush encroachment took place and re-invasion by tsetse flies was only a matter of time. For example, millions of dollars in foreign aid have been spent in various countries for bush clearing operations using expensive heavy machinery. Because the local people were neither ready nor prepared to use the cleared areas for intensive agriculture or grazing, resprouting of the trees and shrubs took place, resulting in denser cover for the tsetse flies than before clearing operations were initiated.

Many species of wildlife are reservoirs of pathogenic trypanosomes and because of this, early parasitologists advocated their extermination. Wildlife destruction was based on the idea that if the preferred hosts, like warthog, could be eliminated, tsetse flies and trypanosomiasis would also vanish. Hundreds of thousands, and more likely millions of head of game have been destroyed with this purpose in mind in Rhodesia, Botswana, Zambia, Uganda and other countries during the past half century. Thus, game elimination was initiated in Rhodesia in the early 1920s, and this was continued until the late 1960s. The officially recorded toll of the systematic hunting operations up to 1963 was approximately 800 000 head of game animals of all kinds (Roth, 1973).

Although these efforts did result in the almost complete eradication of some game species, they were not really effective in the elimination of tsetse flies because the populations of game which managed to survive usually increased, and suitable habitat conditions for the flies continued to exist. It has also been demonstrated that many small mammals play a role of alternate hosts for trypanosomiasis, which makes it much more difficult to control the disease.

It is almost unbelievable that it should have taken three decades of game slaughter after World War II to convince the authorities concerned that this approach was basically inef-

TAKING BLOOD SAMPLES IN AN AFRICAN VILLAGE IN THE SEARCH FOR SLEEPING SICKNESS
a disease of remote places

fective. If the game that was destroyed in the slaughtering operations had been properly used, presumably these actions could have been excused. But, in fact, most of the game was left where it was killed without any use being made of it.

The environmental impact of insecticide applications has also been considerable and environmental contamination has not been sufficiently considered. Side-effects have been reviewed by Koeman and Takken (1976), based on studies made mainly in Botswana, Kenya, Nigeria, Uganda and Zambia.

At present insecticides are applied on a large scale in most tsetse control programmes of the 19 African countries for which information is available. In the majority of operations, DDT, dieldrin or endosulfan have been used either in ground sprays or by aerial spraying. But during the past decade aerial applications have become predominant because fly belts are very extensive and, in general, this method is cheaper and faster than ground spraying.

Many efforts have been made to transfer the insecticides as efficiently as possible to the flies. In aerial spraying this may be achieved by a proper choice of the type of aircraft, atomisers, spray formulation and selection of vegetation to be sprayed. Unfortunately, quite often insecticides have not been applied carefully or were deposited beyond the confines of the target area because of wind drift. The need for skilled pilots should be stressed to ensure effective application with minimal adverse impact. They should be specially trained for this work.

In general, the range of non-target species affected by helicopter applications, and the resulting damage to the environment, are larger than after more discriminate ground spraying.

Ground spray techniques are particularly effective against those species of Glossina which are, at least seasonally, somewhat restricted in their distribution. Aerial applications of non-residual insecticides, involving five treatments at approximately three

weekly intervals, seem to have been successfully used in Zambia, Botswana, and elsewhere. However, the degree of expertise required for carrying out such control programmes is not often available, and also hard to apply. For it involves discovering what is really going on in a "controlled" tsetse population, and among the livestock populations in regard to the actual incidence of new infection, its real impact on production and its sensitivity to drugs. Such problems and difficulties should be carefully weighed before accepting control commitments.

Most insecticide applications studied to date involved extensive deaths among many kinds of mammals, reptiles, amphibians, fish and non-target insects.

Koeman and Takken (op. cit.) arrived at the preliminary conclusion that, in general, mortality in non-target wildlife species continues for a longer period after dieldrin applications (2 to 3 weeks) than after endosulfan applications (approximately one week). There are also differences as far as the spectrum of species affected is concerned: dieldrin tends to affect larger predators while endosulfan does not, but the latter tends to have a more dramatic effect on cold-blooded vertebrates.

As far as long-term effects of aerial spraying are concerned, insectivorous bird populations in particular are severely depressed in numbers and certain species virtually disappear in the treated areas. The latter conclusion refers to results obtained one to two years after application of the pesticide (Ibid.). There are also indications that organisms at the apex of a food chain, like raptors, are most seriously affected.

Long-term effects on non-target invertebrates, fish and other cold blooded vertebrates have not yet been studied in detail. It has been shown in various studies, however, that in particular DDT and dieldrin give rise to measurable residues in fish and other biota.

The problem of environmental pollution may be compounded by concentrations of insecticides in aquatic ecosystems, such as lake basins of central Africa, which lose most of their water by evaporation and not by discharge to the sea.

As for curative and preventive treatment of cattle, the problem is that such treatments must be constantly repeated. At present, immunization of cattle and biological control of tsetse through the introduction of predators are only remote possibilities. And it should be remembered that it is essential to adapt control methods to prevailing local conditions. Usually it is necessary to combine several techniques.

In control situations, the degree of supervision and assessment which has to be exerted in the surveillance and treatment of infection and the evaluation of drug resistance cannot at present be carried out on the scale required by most of the countries

DAHOMEYAN LAGOON CATTLE, FAMOUS FOR RESISTANCE TO SLEEPING SICKNESS
a programme to keep the breed pure

involved. These problems of development cannot be readily overcome because they are inherent to the socio-economic structure of the rural community concerned.

Control campaigns can be successful only if local governments carry them on relentlessly: even a brief interruption might allow the tsetse fly to re-invade pest-free areas, thus ruining previous efforts.

an increase in human density and use results in the clearing of bush and the elimination of most wildlife on which tsetse flies normally feed. Under such conditions, trypanosomiasis can no longer be a problem because neither the habitat nor the vector or sufficient alternate hosts exist any longer.

The main objective in reclaiming land from tsetse infestation or in controlling infestations is to increase

Tsetse control operations should be made an integral part of land-development programmes, to avoid under-exploitation — or over-exploitation — of tsetse-cleared land and to minimize undesirable ecological consequences.

Agricultural development of tsetse-infested lands must be reconciled with conservation needs to ensure long-term optimum productivity of these lands. With this in mind all existing natural

AERIAL SPRAYING IN EAST AFRICA
more difficult than it appears

Three major ecological conditions are possible as a result of tsetse-control operations:

- Without an integrated approach to the problem, and especially to the use of land freed from *Glossina* infestation, the disease could easily spread again.

- The eradication of tsetse flies can create an unstable situation, whereby the indigenous ecological and physiological restraints which controlled the disease in pre-technological Africa are disrupted.

- A stable situation is created when meat, milk, and other food supplies for the local community. Yet if this objective, at the same time, damages wildlife resources, causing overgrazing and in general downgrading of the land, these negative aspects should be evaluated against it.

Destruction of the wildlife resource in favour of cattle development can only be justified on sound ecological, social and economic grounds. If it can be proven, on these grounds, that wildlife utilization should be continued or improved on the basis of better management, wildlife should be maintained.

resources should be considered within the framework of multidisciplinary land-use planning.

But under present conditions sound land utilization is not easy to attain in tsetse-control situations in development areas. The danger of overgrazing if the growth of herds and land-use are not properly planned and controlled will continue to prevail and rapid bush encroachment may ensue, causing tsetse flies to spread again. Therefore, tsetse eradication schemes that are not followed up by properly designed and executed land-use and development programmes will

only result in increasing the impact of man's activities on an environment that is ever less capable of sustaining it. In such cases the process of land degradation can only accelerate.

Finally, it must be realized that large-scale elimination of tsetse flies without consolidation of the cleared areas by agriculture creates a situation in which any reduction of expenditure on farming, or relaxation of effort will be followed by catastrophic outbreaks of trypanosomiasis.

Specialists charged with the control of tsetse flies and trypanosomiasis will no doubt argue that total eradication of both flies and the disease should be their ultimate objective. However, several arguments may be invoked to point out the futility of this approach. In the first place, it would be a most costly undertaking; and, secondly, would it be a worthwhile effort from the land-use point of view?

It would seem advantageous in many instances to keep all large and some small tracts of marginal lands for wildlife conservation purposes.

Marginal land on poor soil, having nothing to gain from modification, should be left alone and could be best used for wildlife management and utilization (Lambrecht, 1966). Wildlife has many advantages to domestic stock in terms of husbandry objectives: it is better adapted to the environment, tolerant to trypanosomiasis and does not demand improved pastures, fencing, shelter and other care required by domestic stock. Under proper management, herbivorous wild ungulates could produce protein and by-products on arid land where cattle raising is not feasible.

Considerable information has already been obtained regarding methods of chemical application, insecticides to be applied and the ecology and population dynamics of tsetse flies, but much more research remains to be done before large-scale tsetse control operations can be considered satisfactory from an environmental management point of view.

Research should be pursued and intensified mainly on genetic tsetse control and trypanosomiasis immunology, because these methods have no environmental side effects. Studies of various methods of biological control and of the possible development of hormonal insecticides should be continued. The discovery of a powerful tsetse attractant would be of great value. New drugs, both for the prevention and treatment of the disease in animals subject to tsetse attack also need to be developed.

It is very important that inexpensive biodegradable insecticides be found, with a high degree of toxicity for tsetse flies and a minimal effect on non-target species. Also, improved methods of tsetse control by means of selection of the most adequate pesticides, formulations and applications should continue, in order to reduce as much as possible the environmental impact.

The various aspects of the biology, ecology and population dynamics of tsetse flies should be carefully investigated, as well as the ecology and status of various non-target species of wildlife actually endangered by insecticide applications. There is also an urgent need to investigate the side-effects of tsetse control operations on non-target insects, fish and certain other vertebrates, particularly in relation to pesticide applications in the moister areas.

Environmental degradation has been progressing at an accelerating rate and there does not seem to be any let-up in the foreseeable future. In fact, conditions seem to be deteriorating even more under the impact of a steadily increasing human population pressure (de Vos, 1975).

Unquestionably, trypanosomiasis has been a major factor in the conservation of forest and wildlife resources of Africa and the areas now infested by *Glossina* constitute a land bank of inestimable potential and importance. Although it cannot be argued that trypanosomiasis infestation should be allowed to continue to guard important forest and wildlife resources, the proposal can be made that, instead, after eradication, all possible efforts should be made to maintain these resources in a good condition. Also, in large-scale operations pre-spray assessments should be made of the ecological value of the various habitats occurring in the areas to be sprayed, and under certain circumstances cleared of vegetation, so as to learn whether damage to fish and wildlife could give rise in certain areas to a serious deterioration of local amenities, such as availability of fish, bee-keeping or loss of species in nature reserves. Special attention should be given to the application of insecticides in vulnerable zones such as riparian forest fringes along streams, which safeguard the survival of many terrestrial savanna species, and also fish species because of the availability of water during the dry season. This implies that attempts should be made to apply pesticides as discriminately as possible by making optimal use of the available techniques and certain combinations of application. For instance, helicopter applications of either dieldrin or endosulfan could be limited to those habitats with a relatively low ecological value, while those with a high value could be sprayed by groundspray techniques, using the most appropriate pesticide available (Koeman and Takken, 1976).

To sum up: although control of trypanosomiasis will be required to allow for an increased availability of human food resources and the elimination of sleeping sickness in tropical Africa, this should not take place while at the same time disregarding or neglecting the ecology of the environment. Proper safeguard should therefore be established to allow for a more satisfactory protection of the natural environment. Under all circumstances, tsetse-control operations should be implemented as part of an integrated land-use and development approach. ■

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The objectives of conservation

J.L. Harley

The aims of conservation of nature are many and complex. There seems to be great diversity in the stated aims of different people and different organizations. Some seem to wish to retain the countryside as it is, essentially an area of pleasure; others would conserve natural communities and their species of plants and animals for scientific study as living museums of wildlife. To still others, the main aim is to use land wisely, that is, to ensure that it produces enough natural products — food, timber and miner-

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A speedboat on the Mississippi River

the problem: to balance recreation, conservation and utilization in one management plan

als — for human needs and the non-material benefits of recreation, amenity and scientific study as well. The author is of this last group.

However, whichever view is taken of its aims, conservation demands that some land be allotted for purposes which are non-productive of material things. Land may be so required totally, as in nature reserves or experimental areas, or in part, as in national parks where constraints are put on the use or the changes of use of the land. Hence much land conservation must inevitably enter into competition with land for production of food, timber and pasture and for mining, quarrying, communications, living accommodation and recreation.

There is no escaping such competition, so it is worth while pausing to think about it. Production of food, wood and other materials from land concerns the whole world. There is a world shortage of food now, and a world timber shortage is expected in the next 25-30 years. We have to accept, therefore, that any act of conservation that has as a consequence reduced biological production in any developed country would seem to mean either a reduction in its present standards of life, or that it would parasitize further a world already suffering shortages, or that it should reduce its population. But must it inevitably mean one of these things? There is a further possibility: that production per unit area of the cropped land must be increased.

The fundamental and immediate effort of conservation must be in elaboration of methods of increased efficiency of crop production, not in the examination of details of nutrient cycling of ecosystems or of habitat requirements of rare plants, although these have their importance. In so far as their efforts concentrate upon increased production per unit area and decreased fossil energy input per metric ton of crop, the researches of such bodies as Britain's Agricultural Research Council are more fundamental to conservation than those of many ecologically orientated research bodies.

There has been a continued upward trend of production per hectare in agriculture in the United Kingdom and in the United States since 1947. It is this kind of increased production per unit area which makes conservation of nature even possible to contemplate.

This competition between conservation for non-material benefits and for scientific research on the one hand and the use of land for production on the other will always exist. It is a problem for politicians to solve, with scientists, especially biologists, providing sound advice on how ecological, agricultural and silvicultural research can improve productivity in the long term and make conservation of non-material benefits possible.

A change of attitude is also necessary for the ecologist. His work is scientific investigation and the scientist is no better at judging good from bad than the next man.

Problems concerning increased production and efficient use of land for crops may include as important components direct conservation of ecosystems and environments. A pertinent example of this is the work being done at the Unit of Tropical Silviculture at the Commonwealth Forestry Institute in Oxford. In the Tropical Pines Project there are several clear objectives. First of these is to provide for lowland tropical areas fast-growing timber trees which can be grown on cut-over or derelict land. These will provide a source of timber and forest products and so reduce the pressure on natural tropical forests for firewood and constructional material. To bring this about the Unit is collecting as wide a range as possible of ecological (perhaps genetic) variants of Central American pines, such as *P. caribaea* and P. *oocarpa*. The seeds collected are being stored and distributed for trials in 40 or more countries. Many of the ecotypes are found already to be in danger of extinction in their native areas, and when this is so the matter is brought to the notice of the countries in which it is taking place. Indeed, the collections themselves are an important step in the conservation of ecotypes, to be followed by their growth in trials or in conservation areas. Implicit in the collection of variants is an intraspecific taxonomic appraisal of the species and a consequent spin-off of taxonomic and ecological problems.

Of course this project is only about seven years old, but it is going ahead in the foreseeable future and it is an example in which production considerations are basic to efficient and effective conservation. The project has been directly financed mainly by the United Kingdom's Overseas Development Ministry with help for a period from FAO. But the invisible input far exceeds the direct finance because of the contributions in scientific work by the 40 or so countries which are involved in the trials. As a corollary to this set of problems the Institute is now joining in with research on the structure and regeneration of natural tropical high forest ecosystems which it is helping to conserve.

This example is not by any means unique in world forestry. The New Zealand Beech Scheme (Kirkland & Johns, 1973; Thompson, 1973) which has been criticized, often unfairly, by extremists as destructive is potentially a similar kind of conservation exercise in a country where the export of wood chips and pulp and the reduction of unemployment might be politically and economically expedient. It should be possible to combine conservation of Nothofagus ecosystems, the conservation of montane soils and water catchment areas, the conservation of amenities and the provision of recreational areas with efficient wood production and processing if the diverse interests combine to refine and perfect the plan as it is now.

The danger of this plan lies not in the plan itself but in the frailty of the human species. The introduction of *Pinus radiata* and *Eucalyptus* spp. into certain areas is a regrettable necessity to make the plan viable in terms of production. It requires

honest self-discipline to limit the areas given to these exotics to the minimum which is essential now and in the future. The risk is that their production will be so much greater than the natural Nothofagus that there will always be pressure to extend their areas.

The application of these ideas to conservation in industrially developed countries is possible. It requires, however, a change of outlook not only of the people in general but of many ecological scientists. For too long, in such countries, drawing their food and raw materials from the whole world was considered a right, and we still have the idea that we can buy what we want. But if we use our land for amenity, recreation or pleasure, if we waste it by inefficient biological production or building, we parasitize the rest of the world for the products of the land. We must realize that efficient production and conservation must go hand in hand.

For the ecologist a change of outlook is also necessary. He must accept that you cannot measure good or bad with a metre rule nor even with a flame photometer or Geiger counter, and the scientist is no better at judging good from bad than the next man. The work of the ecologist is to carry out scientific investigation, to predict what changes will take place in the distribution of organisms in the survival of species or structure of ecosystems if this or that constraint is put upon them. Only by scientific work of this kind with no overtones of good or bad or quality judgements can conservation be furthered by ecologists as such.

It seems to me that in the narrower view of nature conservation we are seeking to ensure the existence for the future of living species in their natural or semi-natural ecosystems. The purposes of these objectives of conservation are to provide a desirable backdrop for the human stage, and also amenity and recreation. We are seeking to conserve living species with their full range of genetic variation, including useful species whose use to man may be negligible or yet unknown. Implicit in the conservation of species is the conservation of the living systems, the ecosystems, of which these species are a part, because in this way their variation, evolution and activities can also be conserved.

All these activities require far more ecological knowledge and ecological insight than we at present possess. And we can classify the efforts required of scientists under the now conventional headings of strategic and fundamental research. Strategic research involves in particular problems of protection and maintenance of areas or biological systems chosen for conservation. Fundamental research involves the study and explanation of the range of variability of species, their environmental demands, their interaction with one another and the structure and physiology of the ecosystems which they together comprise. The carrying out of such research requires precise objectives of conservation of each particular area to be clear and we can discern two broad kinds of objective: one, to conserve an ecological situation as it exists and the other to conserve an ecological area for scientific investigation. These objectives are different, although they may at times be combined.

Upward trends for production per hectare in agriculture are what make it possible even to contemplate nature conservation in industrialized countries. We must realize that conservation and efficient production go hand in hand.

The first consideration of importance in the conservation of an ecosystem as it exists is to determine its status, that is, the factors which tend to maintain it in its present state and those which promote most rapidly its change. I think that to me the most enlightening contribution to the consideration of this general problem was Dr. A.S. Watt's presidential address to the British Ecological Society in 1947, "Pattern and process in the plant community." This paper graphically illustrated a well known but inadequately appreciated feature of ecosystems — that they are compounded of parts, each of which is not stable but passing through a series of changes dependent on growth, senescence and regeneration of the plants of which it is compounded and with these changes the consequent changes in the dependent animals. This thesis emphasizes that there must in theory be a minimum area which can be maintained in constant structure. The concept of such a minimum area is founded on probability. The probability that calamities such as flooding, wind will occur and so on are rare. If we take these relative improbabilities into account our required area is increased. The impact of such infrequent but highly influential factors has been emphasized especially in the study of forest communities, as for instance by Dr. T.C. Whitmore in the Solomons (Whitmore, 1974), but it is of importance in many types of community.

However, there is yet a further complicating feature; this is the recognition of the relationship of an ecosystem to the surrounding pattern of other such systems. An illustration of this is the example of the raised bog. Here we have a pattern of ecological communities exactly arranged and compounded to give a total ecosystem whose structure depends on their spatial and lateral arrangement in the context of topography. The central raised area of ombrogenous peat is dependent on the existence of the less acid lag which causes any drainage water containing bases to be carried away without affecting the central acid region. The change in structure from down-slope to up-slope in the central peat area is a change from Calluna-dominated relatively static conditions to Sphagnum-dominated peat-growth conditions which depend upon a maintained

high-acid water level on the up-slope side. The whole could be conserved, but the parts cannot really exist without the whole. This applies to many ecosystems.

This elementary example was chosen to emphasize that conservation of the *status quo* demands a detailed knowledge of the ecological situation and usually, even now, considerable research in any particular case.

Ecological research, research upon the interaction of organisms and their effects upon one another requires areas, open-air laboratories, where observations can be made and experiments done. In experimental work, rather than pure observation, the ecologist may destroy his experimental materials as surely as does a physiologist or biochemist. Consequently areas conserved for ecological research are of two kinds, those carefully managed or controlled so that they remain stable or undergo change while being observed and recorded by ecologists making the minimum disturbance; and those in which ecosystems are disturbed, or to use modern jargon, "perturbed," that is, subjected to destructive sampling for experimental purposes. Of course these two kinds of activity are not entirely separate; sampling which may be destructive to a small-scale community may be irrelevant to a large ecosystem. Nor does ecological work require only natural or semi-natural diverse systems: much can be learned from artificial situations. A highly pertinent example of this can be found in the advantages of the uniformity of a perennial crop like a forest plantation for the initial studies of complex problems. Their value has been demonstrated extremely well by Ovington (1962), for instance, in his widely quoted work on nutrient cycling. In a similar way Mr. P.F. Entwistle and his friends in the Unit of Invertebrate Virology of the Commonwealth Forestry Institute, Oxford, are using the uniformity of spruce plantations in Wales to study the movement and spread of pathogens in a population of insects. The nuclear polyhedrosis virus of the spruce saw-fly has provided an example for study not only of the spread of the pathogen but also its effect on the host population and on the populations of predators and food plants of that host — a study both of direct ecological and economic relevance. The complexity of a natural community would impose almost insuperable complications until the initial work has been done.

Whatever the aims of the conservationist, conservation demands that some land be allotted for purposes which are non-productive of material things.

When areas or ecosystems are set aside for ecological research the objectives for their use must be clear and must be planned in great detail. Planning how to use natural experimental areas must in the long run be as detailed as that of the experimental plans at Rothamsted or any other field station. If it is not, complicated errors of interpretation will result and great confusion caused. Indeed, over and above curiosity are the more mundane ecological problems of land use directly and intensively relevant to pure research.

To complete the cycle, let us ask the question, "Can we increase the ecological productivity of land like we can increase the agricultural productivity?" The answer is *of course we can*. There are great and interesting problems concerning the ecology of destroyed and derelict land, pit heaps, slag heaps, mining spoil, sand and gravel quarries and the like. Here there are real problems of conservation, and there are problems of resistance of organisms to toxic compounds in the soil and its genetic variation. If such areas of land can be used for experimentation and following that for amenity, recreation, pleasure and wildlife, they increase available space and reduce the competition between food and essential production and conservational ecology.

One of many experiments going on at the moment is the work of Chadwick (1973a, b) on pit heaps and mining spoil. The experimental work of his group has included research on the weathering of soil materials, leaching of substances and toxic chemicals, origins of soil acidity, tolerance of species and their genotypes to soil environments. Recreation, amenity and pleasant areas have been created out of a mess as a result of their work.

Conservation of nature is a large and extensive enterprise. It is an international or global enterprise and it has to be paid for. It is an activity not to be entered upon with prejudice or emotion but coolly and scientifically. It requires a consideration both of the physical needs of man as well as his intellectual needs. Conservation should consider the beauty of the countryside. Some think that wilderness is essential to this beauty; but aesthetic uplift can sometimes also be given by a countryside where every possible square centimetre is given to production and only the rocks are left untouched. ■

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Silviculture in the People's Democratic Republic of Yemen

A.S. Bilaidi

Prior to 1965 a forestry service did not exist in the People's Democratic Republic of Yemen and the chief agents of introduction of exotics were the municipality of Aden, the British Army, the Ministry of Agriculture and individual plant lovers. During this period no accurate records were kept. The planting of exotics was limited to the municipal gardens of Aden and Sheikh Othman.

An attempt at introduction was made in 1965 when a British Forest Officer, S.F. Rawlins, was appointed for one year to carry out some limited activity resulting in seedlings later planted around the resident quarters of agricultural stations for shade and ornamental purposes. Mr. Rawlins filed a report on his activities at the end of his tenure.

The present phase of forestry operations began in 1968, with the creation of a forest section as part of the Agricultural Research Station. Since then the section has developed intensively and the basic forestry foundations have been identified. The section is now managed by a selected team of national and international qualified foresters. The introduction, propagation and planting of exotics is being carried out on a large scale, mainly under irrigation, in the shape of wind barriers, roadside plantation, sand dune fixation and afforestation and general planting for protection and ornamental purposes around social and economic institutions all over the

Acacia tortilis *found growing as far as the Empty Quarter*

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Table 1. — Statistical data on growth and yield for exotics planted as windbreaks in four state farms in the People's Democratic Republic of Yemen

Locality and date of planning	Tree Species	Mean height	S.[1]CV.[2]	Mean diameter	S.[1]CV.[2]	Average volume
		Metres	%	Centi-metres	%	Cubic metres
Amgibla State Farm November 1973	*Azadirachta indica*	3.5±0.8	2.28	7.4±1.7	22.9	0.016
	Eucalyptus camaldulensis	7.09±3.2	45.0	14.4±3.9	27.0	0.129
	Casuarina equisetifolia	6.9±1.6	23.2	9.4±2.2	23.4	0.052
	Conocarpus lancifolius	3.6±1.5	36.0	5.3±1.8	33.9	0.011
	Albizia lebbek	4.1±1.2	29.0	11.6±3.9	33.6	0.051
26th Sept. State Farm March 1974	*Azadirachta indica*	4.5±1.9	42.2	4.8±1.4	29.0	0.011
	Casuarina equisetifolia	6.4±1.8	28.12	6.4±2.7	42.0	0.029
	Conocarpus lancifolius	7.5±1.2	16.0	11.5±2.7	23.8	0.076
Lenin State Farm October 1970	*Albizia lebbek*	10.7±3.2	29.9	26±7.2	27.6	0.658
	Conocarpus lancifolius	11.7±3.4	29.0	15.3±3.5	22.8	0.241
	Eucalyptus camaldulensis	15.13±4.6	0.3	19.23±3.1	16.1	0.468
6th Conference State Farm April 1974	*Albizia lebbek*	3.9±1.7	43.5	3.9±2.5	64.1	0.081
	Prosopis cinerea	5.2±0.85	16.3	6.58±3.7	56.2	0.023
	Acacia mellifera	1.5±0.5	33.3	4.2±0.9	37.5	[3]
	Azadirachta indica	2.8±0.7	25.0	2.4±0.9	37.5	0.003
	Casuarina equisetifolia	6.0±1.4	23.3	3.9±1.9	48.7	0.015
	Conocarpus lancifolius	5.3±0.8	15.0	6.3±1.4	22.2	0.017
	Eucalyptus camaldulensis	6.0±1.8	30.0	5.1±2.1	41.1	0.018

Notes: [1] S. = Standard deviation. — [2] CV. = Coefficient of variation. — [3] Enumeration carried out in October 1976.
The first farm represents middle heights and the latter three represent coastal plains.

adaptable to the prevailing environmental conditions in the country. The statistical data on growth and yield for some selected species in four state farms of different soil, moisture conditions, and altitudinal ranges are presented in Table 1. In this *Albizia lebbek* and *Eucalyptus camaldulensis* attained the maximum height-diameter and volume growth under similar treatments. When planted in the Lenin State Farms in 1970, at 4 m and 6 m apart respectively, *Eucalyptus camaldulensis* produced 117 m³/km and *Albizia lebbek* 109 m³/km. One m³ of their timber sold at 7 and 10 Dinars, standing over bark, in the local market.

THE EFFECT OF BROWSING
Maerua cassifolia

country. The Forestry Section keeps regular records of its various operations. Many are published by FAO and now a considerable literature is available for revision and documentation purposes.

P.D.R. Yemen is a vast country, open to strong winds and shifting dunes which not only threaten agricultural lands but also menace communication lines, man and his livestock and social and economic development projects. The country faces a serious shortage of forestry products; and already large quantities of wood are being imported from abroad and must be paid for with foreign currency which is very much needed for other imports. Natural forest resources have greatly deteriorated as a result of adverse climatic and biotic factors and the absence, until recently, of a forestry service.

In areas where soil and moisture conditions are favourable, especially in the fertile wadi Deltas, the establishment of windbreaks, shelterbelts, and sand dune fixation and afforestation would provide — besides protection, the most urgent need for the country's agricultural economy — substantial valuable amounts of timber, fuel and other intangible products. This can be achieved through the introduction of fast-growing exotics of high-yielding varieties and those which are most

Three main nurseries in the country are managed by the forestry section. These are located in El-kod (coastal plains), Lodar (mid-altitude areas) and Hadramout (Hadramout plateau). They were established in 1968, 1972 and 1973 respectively, and are all engaged in production of seedlings from broad leaves except the Lodar Nursery which produces a small number of coniferous species for research purposes.

● *Eucalyptus camaldulensis* was introduced from Australia in early 1965.

It was first planted at the El-kod Research farm together with 27 species of other *Eucalyptus* and selected later on for large-scale propagation. It grows straight with a good diameter-height symmetricality. In incipient stages of growth it needs protection from the windward side in areas having strong winds. The horizontal crown diameter ranges from 1.75 ± 0.33 m to 1.92 ± 0.36 m after the first year of growth. After six years it attains an average height of 15.13 ± 4.6 m and a coefficient of variability of 0.3 percent. The average diameter is 19.23 ± 3.1 cm with coefficient of variability at 16 percent. Wood production/km over a six-year period is estimated at 117 m^3. It attains maximum growth and wood production at Wadi bottoms where light alluvial soils and water resources are favourable.

Boswalia (*Louban gum*) *for frankincense*

Tending a nursery of Eucalyptus camaldulensis

● *Albizia lebbek* is found growing in municipal gardens in Aden and no correct records are available about the date of its introduction. Seeds were collected from mature stems of good morphological characteristics, propagated and planted in different localities under irrigation. It is a more vigorous grower than A. *nilotica*, and if watered on a deep soil, develops into a large tree. It will grow satisfactorily on a water table at 8 m, as at El-kod.

It regenerates quickly when coppiced; its leaves form good fodder for stock. It gives a very valuable timber with hard wood but is not so drought resistant as Sunt (*A. nilotica*), particularly in its incipient stages. It is suitable for growing around floor irrigated or well-irrigated farms; it is deciduous whereas Sunt is evergreen, and produces much denser shade than Sunt. It is a common tree in the Abyan and Lahej areas. In six years it produced 109 m^3/km when planted 6 × 6 m at the Lenin State Farm under tubewell irrigation. It is planted as windbreaks, roadside and amenity plantations and known locally as " mity ".

● Neem (*Azadirachta indica*) is a fast growing tree and more to be compared with *Albizia* than Sunt, though faster growing than either. Not so large as *Albizia*, its timber is valuable and sold at 10 Dinars/m^3 at the local market. It is not so drought-tolerant as Sunt. It suffers from wind mechanical effect at early stages of growth but resists at later stages. It coppices freely and regenerates prolifically from seed. It is an evergreen, casts a fairly dense shade, and is good for growing along water courses. The leaves are suitable for fodder but not so palatable as others; its wood is close grained and hard. In 26 months of growth it has attained an average height of 2.8 ± 0.7 m and a coefficient of variability of 25 percent, a diameter of 2.4 ± 0.9 cm and a coefficient of variability of 37.5 percent. It is a tree common in the Abyan and Lahej delta. In 1976 chlorosis of the leaf was noticed on old (15 years and above) trees, which suddenly results in drying of top branches and, later on, on total death of the trees. Were this disease to spread it would cause much damage. The incidence now is limited to individual trees and does not yet involve a large scale infestation but it causes uncertainty as to future plans for expanding plantations. The case is now under serious study at the pathology section in the El-kod Research Station.

● Damas (*Conocarpus lancifolius*) grows fairly rapidly if well irrigated and produces a tall-straight trunk. It is not particularly drought resistant but will grow slowly on a water table of about 8 m deep, if initially watered to the stage of establishment. It

attains a good diameter/height growth if given enough planting space. At the Lenin State Farm it was planted in late 1970 at 1½-2½ m apart. There was serious competition among trees both in root and crown zones which resulted in poor growth and yield. It has attained a height of 11.7 ± 3.4 m with a coefficient of variability of 29 percent. The diameter attained was of 15.3 ± 3.5 cm and the coefficient of variability of 22.8 percent during a little less than six years. It attained a height of little more than *Albizia*, but the latter overcomes it in diameter growth, and thereby in volume production of wood.

Casuarina equisetifolia was introduced from South Africa through Dr. Lavranos who was doing studies on succulent plants of southwest Asia and included the People's Democratic Republic of Yemen in 1968/69. It was propagated at the El-kod Forest Nursery and planted first on a small scale. Because of its rapid growth and conical shape it was favoured among farmers for planting as windbreaks. This added to its promising adaptability, encouraged its expansion in the process of propagation and planting. It has now become one of the trees planted as windbreaks. The *Casuarina* is not at all drought resistant and will dry back if not regularly irrigated in areas of less than 100 mm of annual precipitation. It is a first class windbreak tree in deep alluvial soils, receiving tubewell irrigation. The best growth examples are at the Lenin State Farm in Abyan Delta. In Amgibla State Farm (mid-altitude area) *Casuarina* attained a height of 6.9 ± 1.6 m and a coefficient of variability of 23.3 percent in three years' time. This brings it next to *Eucalyptus camaldulensis* as compared to *Azadirachta*, *Conocarpus*, and *Albizia* spp.

Prosopis cinerea was introduced from Hadramout in 1973 and propagated in El-kod Forest Nursery. It was planted in 1974 at the El-kod Forest Research Arboretum. In the same year some saplings were planted at the Sixth Conference State Farm for demonstration purposes. It seems to be growing vigorously and with excellent performance. Based on the statistical data collected, the tree attained an average height of 5.2 ± 0.85 m and a diameter of 6.58 ± 3.7 and a coefficient of variability of 16.3 and 56.2 percent respectively, in about 26 months' time. It is drought resistant, having a spreading crown from 1½ m above ground level to the top. This makes it an excellent tree for windbreaks in areas having strong wind and shifting sands. It has a deep root system which can draw moisture from deep layers of the soils. The tree coppices freely and is excellent for fodder.

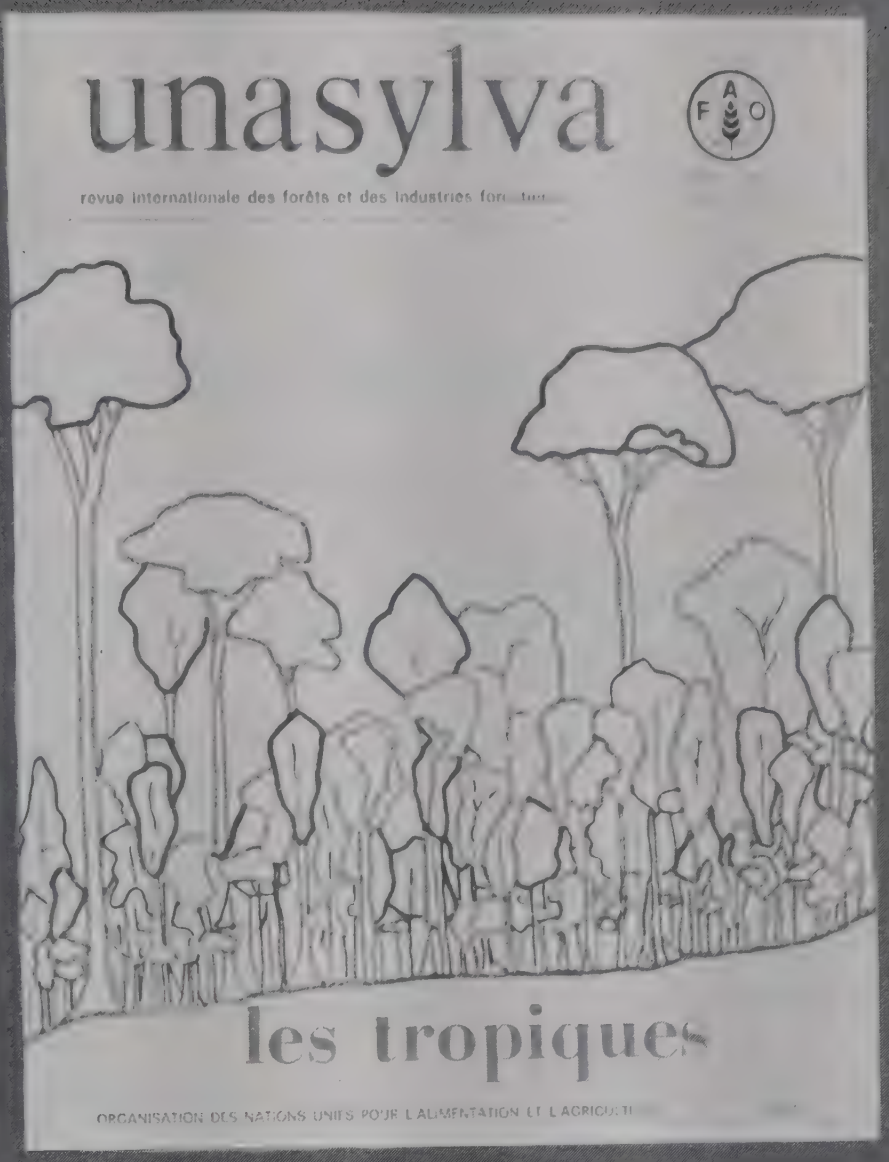
Acacia mellifera was introduced recently from Sudan and was planted in the arboretum and Sixth Conference State Farm in 1974. It was also planted for demonstration purposes. It seems to be good for hedge or anti-animal barrier if closely spaced. In early stages of growth it is vigorous and drought resistant, attaining a height of 1.5 ± 0.5 m and a crown diameter of 4.2 ± 0.9 m with a coefficient of variability of 33.3 and 37.5 percent respectively, during a 26 months' period. In the arboretum it flowers and produces seeds two years after planting. It is a good bee attractor during flowering time. ■

Table 2. — Tabulated data showing growing stock production of exotic species in El-kod Forest Nursery from 1970-76

Species	1970	1971	1972	1973	1974	1975	1976	Total
Azadirachta indica	722	1 616	2 957	9 844	6 576	16 391	25 012	63 118
Conocarpus lancifolius	1 969	1 274	7 129	1 451	6 140	7 660	6 206	31 829
Acacia cyanophylla	1 169	394	504	—	—	—	—	2 067
Albizia lebbek	1 703	1 885	609	6 439	6 381	2 298	3 470	22 785
Caesalpinia spp.	355	784	940	1 951	2 453	1 444	2 241	10 168
Parkinsonia aculeata	1 906	3 137	1 043	1 840	3 006	679	1 664	13 275
Thespesia populnea	1 741	991	1 398	1 063	3 968	6 347	5 234	20 742
Casuarina equisetifolia	515	1 250	11 949	11 064	10 387	13 134	5 759	54 058
Delonix regia	—	274	433	1 363	563	1 147	1 514	5 294
Eucalyptus camaldulensis	—	1 950	333	3 919	4 520	1 798	1 683	14 203
Prosopis spp.	—	125	423	372	649	212	174	1 955
Dodonea viscosa	—	409	320	698	1 000	2 873	579	5 879
Miscellaneous [1]	—	—	—	—	—	—	—	19 227
	10 080	14 089	28 038	40 004	45 643	53 983	53 536	264 600

[1] Miscellaneous are from *Acacia tortilis, A. melifera, Lawsonia alba, Lantana camara, Peltophorum inerme, Kigalia pinnata, Ponganica glabra. Nerium oleander, Hibiscus* spp. etc.

CUT DOWN FOR TIMBER
Ficus vasta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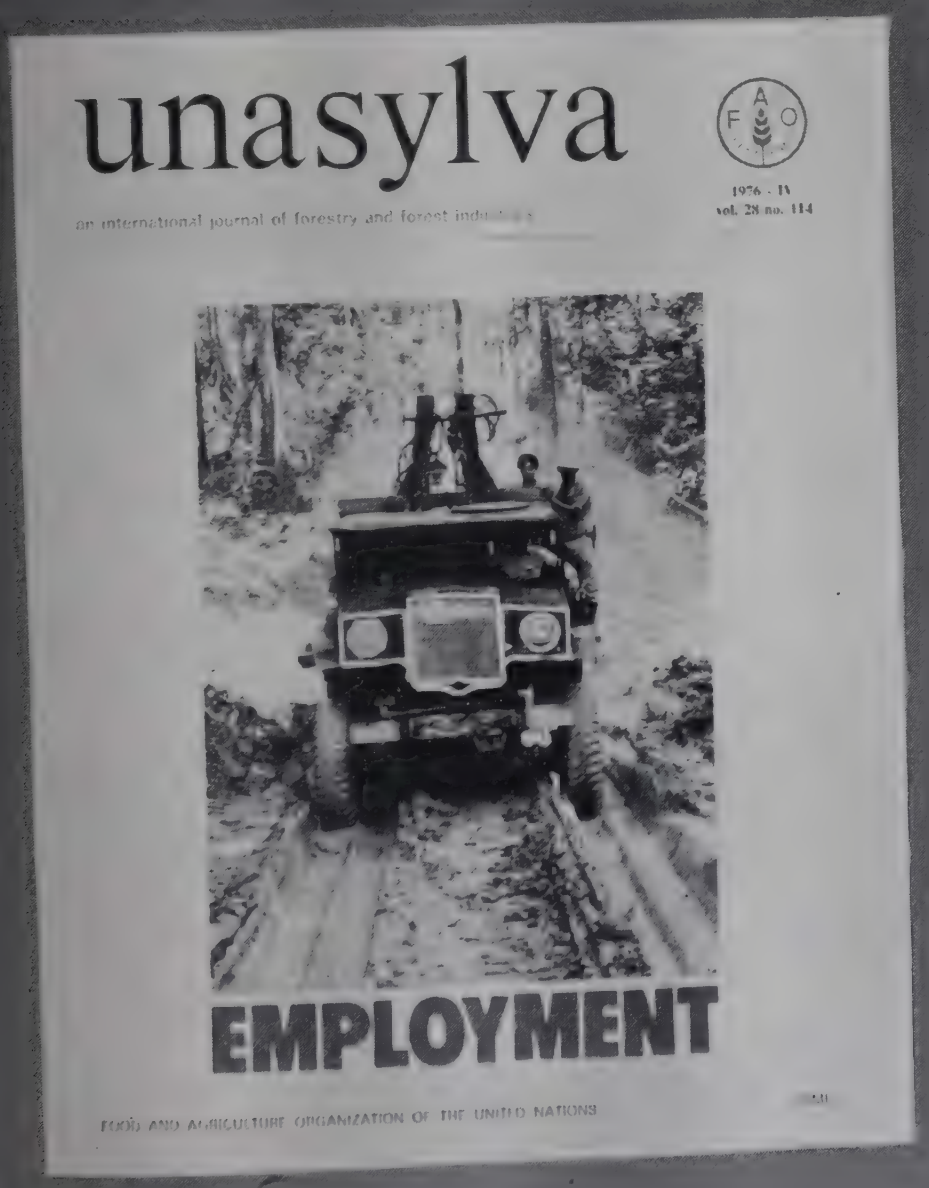
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The Eighth World Forestry Congress

The Djakarta Declaration

- ☐ **Warnings to governments about the disappearance of tropical forests.**
- ☐ **The urgent need for fuel wood and charcoal in " the poor man's energy crisis."**
- ☐ **Industries can be scaled to the economies of developing countries, rather than just to economies of scale.**
- ☐ **Watershed management problems throughout the world need more attention, and the means to deal with them are at hand.**

The following is the official declaration of the Congress issued in Djakarta

1. Indonesia was the generous host to the Eighth World Forestry Congress held in Djakarta from 16 to 28 October 1978. The Congress drew participants from 95 countries and 17 international organizations.

2. The Congress reaffirmed the formal declaration of the Seventh World Forestry Congress, which had as its theme " The forest and socio-economic development. " The Eighth Congress, with the theme " Forests for People," examined in depth how forestry might best serve human beings, individually and collectively. In consequence, the Congress declared that the world's forests must be maintained, on a sustainable basis, for the use and enjoyment of all people.

3. The forest is a resource already under pressure from millions of people, striving to lift their standards of living. Since the last Congress, hundreds of millions more people are having to depend on an ever-decreasing area of forest. This situation places on governments and on their forest administrations an even greater responsibility than ever before to arrest degradation and to manage every hectare of forest to best advantage and in the best interest of all people. The Congress recognized that this was a major challenge to the forestry profession, and to all those in any way concerned with forestry activities.

4. The Congress was not dismayed at this challenge. It recognized that the world's forests were still vast in extent, that they represented a renewable resource, that their biomass was by far the largest of all vegetation types, that the potential for sustained growth and production and for expansion was still immense. The Congress, however, and with a grave sense of urgency, stressed to all governments that time is running out and that unless effective measures are taken immediately forests will be unable to make the future contribution to mankind of which they could be capable. Furthermore, and because of the close and direct link between quality and quantity of water on the one hand and the extent and state of the forest resource on the other, the Congress recommended that every effort should be made in order to prevent water becoming so scarce as to affect biological production adversely.

5. Being acutely aware that the human population is still increasing by 70 million people every year, the Congress paid particular attention to the role which forests can play in improving the conditions for agricultural and livestock production, for instance through shelterbelts, regulation of waterflow, erosion control, as well as a source of supplementary animal fodder in dry periods. The Congress urged an ever greater effort to use forests for these indirect means of ensuring and increasing food production. Moreover, foresters should look beyond their forest reserves to areas where the planting of trees can be of major benefit to people and to agriculture other than for the direct harvesting of timber.

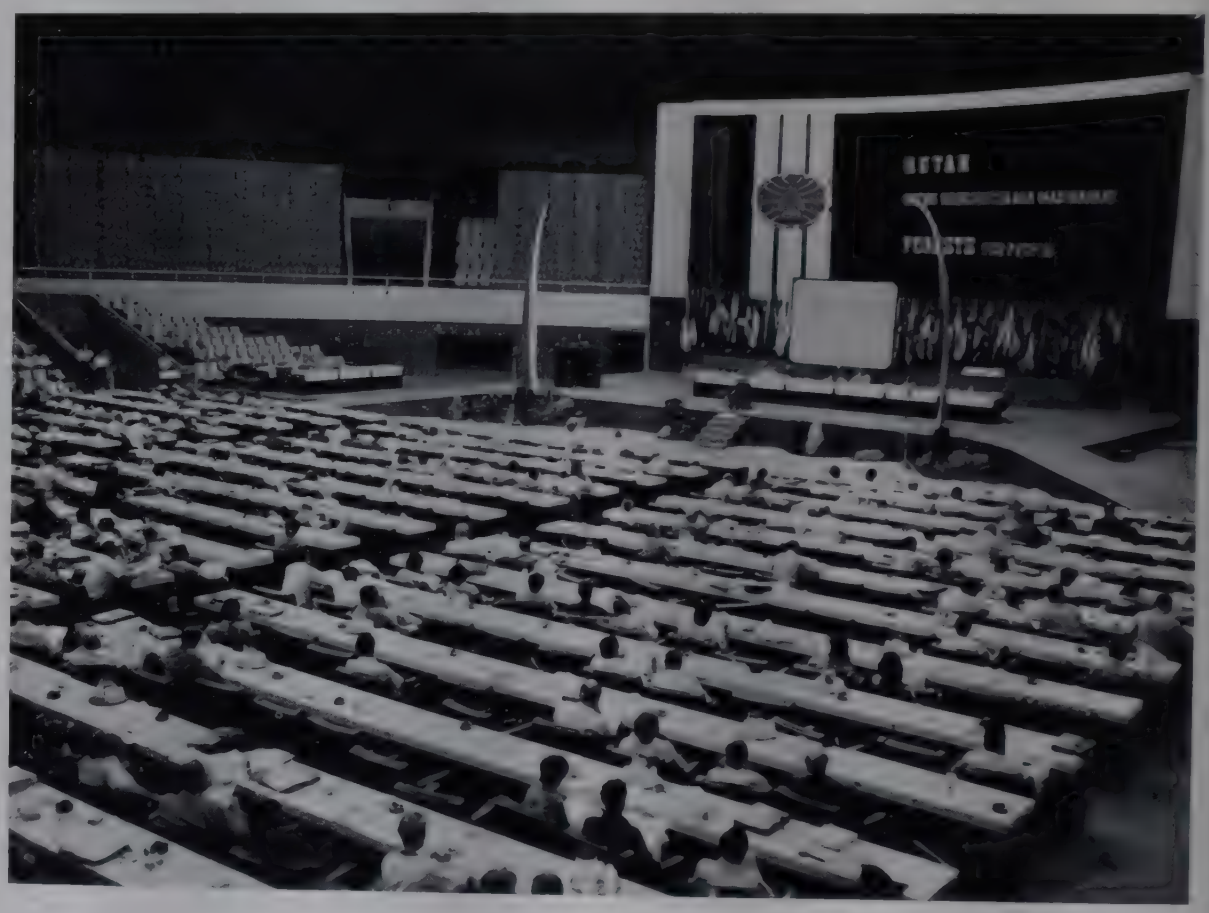
6. By reason of the gravity of world food shortages, indirect means are not enough. In many countries, an enlarged concept of multiple-use forestry is required, one which encompasses the more direct production of food from forests and forest trees, as well as from wild fauna. The Congress also called attention to the

fact that in recent decades floods, droughts, and the spread of deserts have increased. This trend will continue unless proper land management, including reforestation, is undertaken by governments with urgency. The droughts and accelerated desertification in Asia, Africa, and Latin America — and the extremely destructive floods in Asia — have caused loss of lives and misery to millions. In recent years, however, there have been many examples of successful techniques in agroforestry which governments can use to halt these destructive trends. The Congress urged an increase in applied research in this field in order to enable governments to deal with such problems effectively.

7. As forests and forest trees are an essential element for maintaining the environmental stability necessary for the continuous production of food by rural communities, and to meet some of their most basic needs, the Congress affirmed that it should be the concern of all in the forestry profession that forestry make its full contribution to the development of rural communities, particularly of the rural poor of the developing world. A commitment to rural development on the part of foresters will be of no avail unless there is a firm commitment on the part of governments. Such commitment must include action to reduce inequalities in the countryside, notably in the distribution of land and in access to social and support services. It means encouraging self-reliance, mutual aid and cooperation. It means recognizing people as the motive force of development, not simply as the passive object of development.

8. Foresters must have the responsibility of managing forest lands and the natural resources existing thereon. Forestry administrations must have the rank, political backing, and effectiveness to discharge adequately such responsibilities to the best advantage of the people.

9. One of the most important changes since the previous Congress has been the energy crisis and its many implications for forestry and forest industries. The Congress was particularly concerned with the "poor man's energy crisis," the growing firewood shortage brought about by population pressure, dwindling forest, and the increased cost of alternative means of cooking and heating. This situation has reduced even further the already intolerably low living conditions of some 1 500 million of the rural poor. Furthermore, the burning of plant residues and animal dung has seriously affected soil fertility and hence food production. The Congress urged all governments in countries with a major requirement for fuelwood, and not well endowed with forest resources, to give the highest priority to its production in appropriate locations, with full participation of local people and suitably integrated with agriculture.



2 000 PERSONS FROM 100 COUNTRIES ATTENDED THE CONGRESS
The major concern was for the tropics

10. The Congress called for better utilization of the forest resource by seeking and practising more efficient harvesting and processing techniques. International organizations as well as developed countries should spare no effort to help developing countries possessing substantial forest resources properly to inventory and manage them on a sustainable basis.

11. Increased oil prices had also had an effect on forest industries and the people directly dependent on them. Often energy costs can be reduced and energy can be saved by more efficient plant design and plant operation, and therefore the Congress urged all forest industries to take steps toward this end with the consideration of a greater use of wood residues, whether industrial or from the forests themselves.

12. The energy crisis has a further and potentially far-reaching implication for forestry — the possibility for forests to become an important source of high grade as well as low grade energy. Because of the interdependence of liquid and gaseous fuels and chemicals, forests offer an equally exciting opportunity for providing the synthetic organic materials so indispensable to modern society and which are now produced from fossil fuels. The Congress brought to the attention of governments and international technical and financing organizations this important new role which forests may be asked to play, urging the early intensification of the necessary programmes of research and development.

13. The introduction of forest management and protection has usually led to welcome increases in productivity

of the land, both forest and farm land. But, unfortunately, this has often not been true of the world's tropical forests — and more than half of the world's forests are in the tropics. Large areas of these forests, all located in developing countries, have suffered significant deterioration in quality and reduction in size. The greatly expanded rate of removals over recent years has concentrated on prime species, often for unprocessed export, and this selective exploitation has left a poorer quality forest, badly damaged. But even more important, and largely unrecognized, is the serious human and ecological problem of shifting cultivation in the tropics. It is responsible for large-scale degradation of both forests and crop lands. Therefore, the Congress emphasized the importance of restoring productivity to present deforested areas, also for the sake of the hunter-gatherer living entirely off the tropical rain forest.

14. Because of this situation, the Congress stressed the need for comprehensive forest land management, industries to be reorganized and new technologies to be adopted in order to use more effectively smaller logs and a wider range of species. It also urged developing countries to undertake further processing and to produce a wide range of products for both domestic consumption and export. The utilization of the forest resource must be aimed at enhancing the welfare particularly of the communities living or working in the forest and, more generally, of all the people of the country possessing such a resource. The implementation of this must be based on an adequate inventory and monitoring of changes in tropical forest cover.

15. The Congress urged that forest services should assume a leading role in evaluating proposals for the establishment of both small- and large-scale forest industries, according to the size of the market and the resource available, as well as the managerial and technical capability of the country. Whereas large-scale forest industries are necessarily capital intensive, forestry is generally labour intensive as often is smaller scale industry. Although mechanization of some activities may be desirable, the important role which forests can play in providing employment suggests that in some circumstances the labour intensive role of forestry should be deliberately preserved, at least in the short term. More modern and sophisticated technologies might be warranted in future if the utilization of the forest resource brings about real development.

COPIES OF THE DECLARATION ON THE LAST DAY
And the last of 531 papers

16. The Congress strongly emphasized the important role which forest products other than timber play in the life of rural communities depending on the forests. These products play a vital role in providing employment opportunities and raising the living standard of rural people, increasing the number of people supported by forests. The Congress therefore recommended that forest services and international organizations should work for the conservation, promotion and rational utilization of such products.

17. The Congress urged governments to take appropriate corrective action, including changes to the social and economic structures wherever needed, with respect to unsatisfactory health, safety, status and remuneration conditions of forest workers. There was an urgent need for a more highly trained work force, and the Congress stressed that governments should devote more resources to the initial and continuing training of workers, technicians and professionals in both forestry and forest industries.

18. The Congress supported the view that forestry should offer equal employment opportunities to men and women, and that steps should be taken to increase the proportion of women employed.

19. Recognizing that forests have an important bearing on many aspects of the quality of life, the Congress stressed that foresters have a responsibility to give a positive lead in regard to environmental impacts and choices between different uses and different mixtures of uses.

20. Stressing also the important role of forests and trees for recreation and tourism, the Congress insisted that the cultural, social and economic needs of people actually living in and near the forests be always considered in using forests for recreation or promoting tourism, and that use should not lead to forest site deterioration.

21. Recognizing that it is important to mankind's future to preserve representative areas of all major forests as gene pools, scientific bench-marks, habitats for wildlife and as examples of man's cultural heritage, the Congress urged all governments to preserve, as part of normal balanced land use, adequate areas of every type of forest and give them full and permanent legal protection as national parks or other protected areas. Efforts should be intensified to search out species of potential benefit to mankind and to develop their use.

22. Research will play an essential role in achieving the goals of the Congress and the objectives stated herein. A sound scientific and technical foundation is required for the wise use of all forest resources. The Congress recommended that research should be encouraged and strengthened for the benefit of people of the world who depend on trees and forests for their economic and social well-being.

23. The Congress drew attention to the necessity for the increasing needs in scientific, technological and managerial information to be met efficiently. Existing forestry information and documentation services should be supported, and their further development encouraged. The activities of international, local and specialized information services should be coordinated.

24. The Congress noted with concern that, if present trends continue and potential demands materialize, there is the prospect of a serious gap between the world's needs for industrial and other wood products and the capacity of the world's forests to supply these and other essential goods and services. This gap can only be avoided if the shrinkage of the forest area is halted, if natural forests are properly managed, if harvesting is more complete and more efficient, if there is subsequent full and prudent use of all products harvested, if large areas of successful plantations are created and intensively managed, and, finally, if the return from forest utilization reaches the communities owning, living, or working in the forests

The Congress called on all foresters to re-affirm their total commitment to resource conservation, resource renewal and resource expansion.

25. In order to strengthen the role of forests for people, especially the poorest sectors of the population, the Congress finally emphasized the importance of:

- the contribution of forests (without detriment to their continued existence for future generations) to the economic development of the least favoured regions;
- the development of international cooperation in inventory compilation and forest-resource management and conservation, particularly in developing countries;
- intensification of forest productivity within the framework of integrated land management;
- the creation of jobs in rural areas.

26. Those governments which have not yet proclaimed an official forest policy are urged to do so, including the relevant principles of this Congress declaration as keystones of their manifesto.

SOEDJARWO
President,
8th World Forestry Congress

Jakarta, 28 October 1978

Flores Rodas new head of FAO forestry

Marco Antonio Flores Rodas, of Honduras, is the new head of forestry of the FAO. He was appointed as Assistant Director-General on 18 September 1978 by Edouard Saouma, Director-General of the FAO.

Dr. Flores Rodas succeeds Dr. K.F.S. King, of Guyana, who resigned to become Director-General of the International Council for Research in Agro-Forestry now being formed in Nairobi.

The new head of the FAO's Forestry Department was born in Tegucigalpa, and is 44 years old. Before joing FAO he was the Forestry Manager, or Chief Forester, of the Honduran Corporation for Forestry Development, which he was also instrumental in founding in 1974. This state enterprise encompasses all phases of Honduras' forestry and wood industry, including the national forest service, logging operations, transport, various forest industries, marketing and domestic and foreign trade in primary forest products. As such it is unique among forestry state enterprises.

Marco Antonio Flores Rodas
HONDURAS

Before 1974 Dr. Flores' career was in various areas of tropical forestry management, logging, national and industrial development planning, and education.

He was Forest Adviser to the Minister of Natural Resources of Honduras and consultant to governments and industry in the Dominican Republic, Costa Rica, Nicaragua and Guatemala.

He served as Director of Forestry at the University of Honduras, Director of the National Forestry School of Honduras and instructor in forest resources at the University of Washington in Seattle.

Following studies in agronomy at the Pan American School of Agriculture, Tegucigalpa, Dr. Flores received Bachelor of Science and Master of Science degrees from the University of Florida and a Doctorate at the University of Washington, all in forestry, in the field of forest management, forest mensuration and applied statistics.

Eating the right leaves in a tropical forest

Edible Leaves of the Tropics, by Franklin W. Martin and Ruth M. Ruberte. Mayaguez Institute of Tropical Agriculture, P.O. Box 70, Mayaguez, 00708 Puerto Rico, 1975. Published jointly by the Agency for International Development, Department of State, and the Agricultural Research Service, U.S. Department of Agriculture, pp. vii + 235, 56 figures, 12 tables. Appendix. Index.

Edible Leaves of the Tropics is a most interesting and useful book, but it is also potentially dangerous.

A quick picture of what it contains may be had from the chapter headings. Following an introductory chapter the book covers:

- The principal edible green-leaf herbs of the tropics.
- Some fruits, vegetables and ornamental plants that also bear edible leaves.
- Common weeds with edible green leaves.
- Tropical trees with edible green leaves.
- Tropical leaves as spices and teas.
- Temperate zone green leaves in the tropics.
- Lettuce in the tropics.
- Tropical leaves that are poisonous.
- Culture and care of green-leafed vegetables.

The following are treated in a class of principal edible green-leaf herbs: various species of *Amaranthus*, New Zealand spinach, the leaves of cocoyams (*Colocasia* and *Xanthosoma*), Ceylon spinach (*Basella rubra*), sweet potato and Knagkong (*Ipomoea aquatica*), water cress (*Nasturtium officinale*), the fluted gourd (*Telfairia occidentalis*), cassava (*Manihot esculenta*), various *Hibiscus* species, water leaf (*Talinum triangulare*), and *Corchorus olitorius*. Also included in the list of major species which will come as a surprise to many, is *Sauropus androgynus*, the Katuk of India and Malaysia. A significant error in this chapter is the statement that "some varieties of *Amaranthus* are purplish with anthocyanin. This is not so, *Amaranthus* and most members of the Centrosperm order do not have anthocyanin pigments but betalain alkaloid pigments (1).

In the chapter on fruits, vegetables and ornamental plants that bear edible leaves, the reader is left with a considerable feeling of unhappiness about the possible consequence of too much experimentation following the reading of this book. For example, page 37, "there is no reason that once carrots have been purchased with tender, edible leaves that these should be discarded in favour of the roots. However, young leaves cause dermatitis to sensitive persons." And on the same page, under eggplant, "as is frequently the case, the leaves, which are seldom used but which are perfectly edible, are more nutritious than the fruits... the fine hairs of the leaf are irritating to many people." On page 39 it is pointed out that the young leaves of *Euphorbia purcherrima*, the common Poinsettia "are not only edible, but highly nutritious." However, in the same paragraph it is warned that the latex is sufficiently caustic to remove hairs from the body, that the gathering of leaves may lead to dermatitis, and futhermore because it is poisonous, the plant should be kept from children who are apt to chew it. On page 41 a very dangerous idea is set out with reference to the genus *Spondias*. "It is known that a number of species of *Spondias* bear edible fruits and it is probable that the leaves of all species are edible." While this may be true, it is a rather rash statement which might tempt people into unsafe experiments.

The danger of transferring belief in edibility from one species to another within a genus should be well known from consideration of *Solanum*, though it is rather surprising that in this book it is pointed out that the young leaves of both potatoes and tobacco are edible. Of young tobacco leaves the authors suggest "the amount normally used for a cooked dish should not be harmful." Less well-known however than the example of the dangers of widespread eating of the leaves of *Solanum* would be the genus *Phyllanthus* (Euphorbiace). On page 41 it is pointed out that two species of this genus bear edible fruits and leaves. These are the Otaheite gooseberry (*P. acidus*) and also *P. emblica*. However, *Phyllanthus engleri* Pax and *P. reticulatus* Poir are both included in Verdcourt and Trump's very valuable book on the common poisonous plants of East Africa (2). They report that a man is recorded as having died within 12 hours after eating three leaves of *Phyllanthus engleri*. Admittedly, the record is open to some doubt.

The chapter on common weeds with edible green leaves is a fascinating one. The first question that the reader will ask himself is "When is a weed not a weed?" The very concept of a weed is one from modern agriculture in which crops are planted in pure stands and anything in an area oc-

cupied by the crop that is not intended to be growing there can be regarded as a weed. But in less developed agriculture mixed cropping is common and plants may grow more or less at random. Is a wild plant that has seeded itself but is nevertheless tended and valued as a food crop a weed or not? Among the plants which these authors regard as being weeds are the purslane, *Portulaca oleracea*. This is certainly sown and cultivated as a crop plant in some countries, and some special varieties have been selected. So much for detailed criticism, though one could continue.

What is very valuable about this book is that there is some prospect that it may help to make the continued cultivation and use of indigenous vegetables, which are well-known to the inhabitants of developing countries respectable. Attempts to replace the eating of Calaloo in the West Indies or Dodo in East Africa by white fleshed, hearty cabbages of much lower nutritional value, may have aggravated nutritional problems in some countries. There has been a welcome trend during the last 10 years for agriculturalists of temperate-zone training to take a more enlightened attitude toward local tropical vegetables, and the present book is a symptom of this trend. On the question of safety, perhaps the best advice which can be given would be the same as for the eating of local mushrooms. Find out what the local people, and particularly the older ones who may be more familiar with customary diet, consider edible. Test its nutritional value and encourage the continuing of its production and use if there are no counter indications.

This is a provocative and important book in spite of any anxieties that it may engender in the minds of readers. It deserves to be widely read by agriculturalists, nutritionists and development planners. It will help to open the eyes of very many people to prospects for the production of food of which they have never dreamed.

C.L.A. LEAKEY
Appropriate Technology, London

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Using people to build roads is not easy

Manual on the planning of labour-intensive road construction, by M. Allal and G.A. Edmonds in collaboration with A.S. Bhalla. International Labour Office, CH-1211, Geneva 22, Switzerland, 1977. 40 Swiss Francs, 253 pp. Soft cover.

The visitor to Geoff Edmonds' office in Geneva immediately notices a small white card pinned to the wall in front of his desk. It reads:

"Any socio-economic phenomenon which cannot be described in plain English but must be described in algebraic notation, is not worth describing at all!"

He practices what the card preaches, since this book is an example of clear and well-argued propositions on a topic which is of crucial interest to the developing world. Anyone who has visited some of the excellent (and appropriate) earth roads being constructed in Kenya under the rural access roads programme will also know that this ILO team has real experience of applying intermediate technology.

The first two chapters of the book cover road planning and road design. Indeed, it is often at these early stages that "the pass is sold" on the possibility of labour-intensive methods being economic in the conventional sense. For example, it is often possible to choose between a number of possible routes from A to B. By choosing a route which avoids hauling earth over long distances and other activities which are difficult for hand labour, labour-intensive methods can often compete in conventional accounting terms as well as being socially beneficial.

In later chapters the authors deal comprehensively with the key areas of cost and productivity. Two men doing one man's work is not intermediate technology, it is plain inefficiency. Although the case for labour-intensive methods does not rest on cost and efficiency comparisons alone, it would certainly benefit from the availability of more hard data and rigorous analysis.

The second part of the book discusses the institutional setting as a background to the appraisal of technologies. After discussing various fiscal and administrative measures which can help to create a more favourable environment for labour-intensive techniques, the authors go on to cover the problems of organization and management posed by the larger labour forces associated with intermediate techniques.

The authors rightly point to the "distinct lack of training" in this sort of management which should be regarded as being an integral part of the duties of a public works department. Special courses are needed and these should be directly related to the projects on which the trainees will subsequently work.

A short final chapter underlines the serious constraint on the application of intermediate techniques which results from the attitude of engineers who often preclude the choice of technologies appropriate to their own environment and social problems. The "one-solution-to-one-problem attitude" is rightly castigated, and it seems sad that the challenge of operating efficiently with labour-intensive methods (which are in reality more demanding in terms of professional skill) is so seldom emphasized in courses both inside and outside developing countries.

Although the price of this volume (40 Swiss francs) may seem high, the book certainly represents a major step forward in the national and human assessment of road construction technologies. Ministries, development agencies and consultants should buy it — and read it!

DEREK MILES
Appropriate Technology, London

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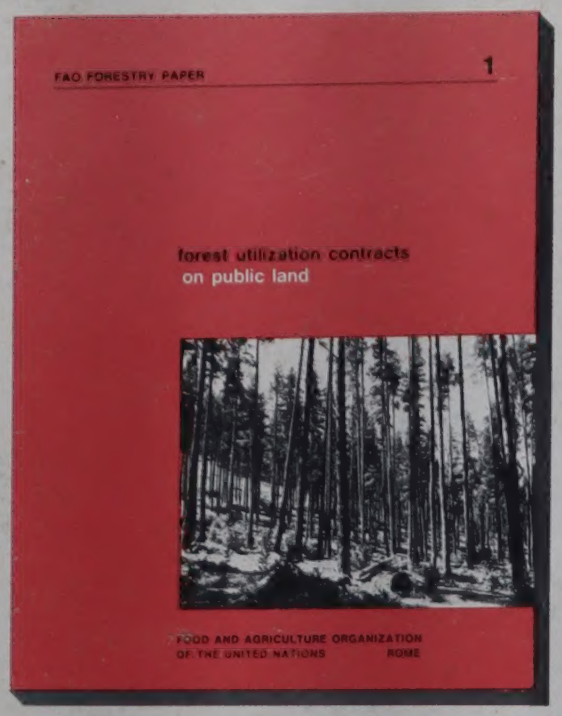

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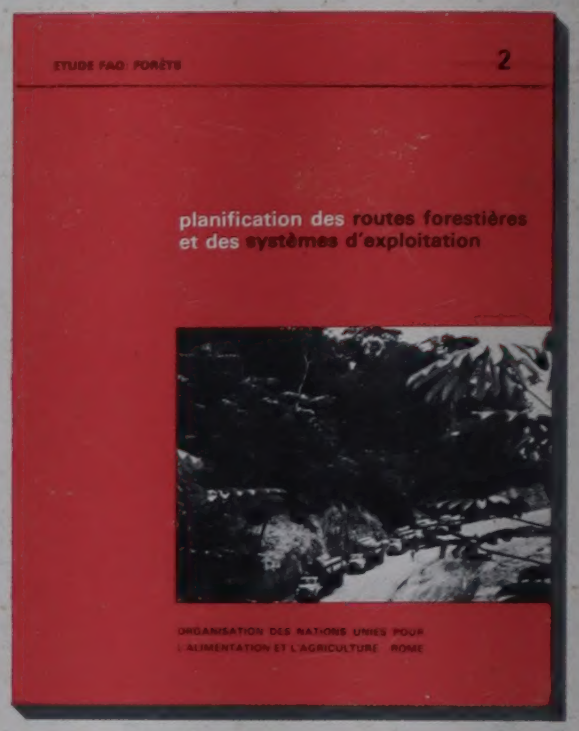

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